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UNITED PLANTERS' ASSOCIATION OF SOUTHERN INDIA

Tea Scientific Department

PROCEEDINGS

OF THE

SIXTEENTH SCIENTIFIC CONFERENCE

1970

(31ST AUGUST 1970)

BULLETIN No. 28

NOTICES:

1. During the year under review the UPASI Tea Scientific Department functioned from the following centres:

   i UPASI Tea Research Station, Cinchona P. O., Coimbatore Dist.

   ii. UPASI Tea Research Sub-Station, Vandiperiyar, Kerala State.

2. It is requested that specimens for laboratory examination be sent by unregistered post to

   The Director,
   UPASI Tea Research Station,
   Cinchona P. O., Coimbatore Dist.

   In the case of specimens too bulky to be sent by post, they should be sent, *freight paid*, by rail or road transport to Pollachi and the way bills sent to

   Messrs. Natesan Company,
   Transport Agents, Pollachi P. O., Coimbatore Dist.

   for collection and forwardal to the UPASI Tea Research Station, Cinchona.

3. Specimens intended for the UPASI Tea Research Sub-Station at Vandiperiyar should be sent direct to

   The Officer-in-Charge,
   UPASI Tea Research Sub-Station,
   Vandiperiyar P. O.,
   Kerala State.

4. It is specially requested that all correspondence be addressed to the Director or the other officers *by designation and not by name,* as this would enable prompt attention even in the absence of the concerned person on tour or leave.

UNITED PLANTERS' ASSOCIATION OF SOUTHERN INDIA

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CONTENTS

	Page
Programme	i
List of delegates, visitors, etc.	ii
Introductory remarks by the President, Mr. N. Bhagwandas	1
Chairman's Welcome Address Mr. D. A. Cook, UPASI Tea Product Sub-Committee	2
Twentyfive years of Tea Research in Southern India Dr. K. S. Venkataramani	4
Diseases as limiting factor in tea production Dr. C. S. Venkata Ram	6
Potassium, a master nutrient for tea Mr. V. Ranganathan	13
Helopeltis - a break through in its control Dr. G. N. Rao	21
Discussion	28
Chemical weed control in tea Dr. K. S. Venkataramani	29
Genesis of fertilizer recommendation in tea Mr. V. Ranganathan	39
Mites, a major economic problem – Recent trends in their control Dr. G. N. Rao	45
Milestones in blister blight control Dr. C. S. Venkata Ram	53
Clonal selection, a method of improvement of tea planting material Dr. K. S. Venkataramani	65
Discussion	75
Delegates' agenda	82

UPASI TEA SCIENTIFIC DEPARTMENT

SIXTEENTH SCIENTIFIC CONFERENCE

(MONDAY, 31st AUGUST 1970)

PROGRAMME

10-00 a. m.	—	'Introductory Remarks' by Mr. N. Bhagwandas, President of the UPASI
10-10 a. m.	—	'Welcome Address' by Mr. D. A. Cook, Chairman of the Tea Product Sub-Committee
10-20 a. m.	—	'Twentyfive years of Tea Research in Southern India' by Dr. K. S. Venkataramani
10-30 a. m.	—	'Diseases as limiting factor in tea crop production' by Dr. C. S. Venkata Ram
10-40 a. m.	—	'Potassium, a master nutrient for tea' by Mr. V. Ranganathan
10-50 a. m.	—	'Helopeltis - a break through in its control' by Dr. G. N. Rao
11-00 a. m. to 11-20 a. m.	}	Discussion on the above papers
11-20 a. m.	—	Break for coffee
11-40 a. m.	—	'Chemical weed control in tea' by Dr. K. S. Venkataramani
11-50 a. m.	—	'Genesis of fertilizer recommendation in tea' by Mr. V. Ranganathan
12-00 noon	—	'Mites, a major economic problem - Recent trends in their control' by Dr. G. N. Rao
12-10 p. m.	—	'Milestones in blister blight control' by Dr. C. S. Venkata Ram
12-20 p. m.	—	'Clonal selection, a method of improvement of tea planting material' by Dr. K. S. Venkataramani
12-30 p. m.	—	Discussions on the above papers
1-00 p. m.	—	Break for lunch
3-00 p. m.	—	Delegates' agenda
4-30 p. m.	—	Concluding remarks by Mr. D. A. Cook
4-40 p m.	—	Break for tea

UPASI SCIENTIFIC DEPARTMENT

Sixteenth Scientific Conference — 1970

Mr. N. Bhagwandas	...	President, UPASI (Chairman)
Mr. P. G. Gurjer	...	Vice-President, UPASI
Mr. D. A. Cook	...	Chairman, UPASI Tea Product Sub-Committee

DELEGATES

Mr. D. W. Mayow Mr. A. G. Forbes	}	Anamallai Planters' Association
Mr. V. Srinivasan	...	Central Travancore Planters' Association
Mr. M. Abraham Varghese Mr. G. Verghese	}	Kanan Devan Planters' Association
Mr. I. A. Ansari	...	Wynaad Planters' Association

VISITORS

Dr. V. S. Kulasegaram Dr. W. M. W. B. Manipura	}	Tea Research Institute of Ceylon
Mr. W. J. Grice Mr. R. Choudhury	}	Tocklai Experimental Station, Assam
Mr. R. L. Narasimhaswamy	...	Director, Coffee Research Institute
Mr. M. Mohan Rao	...	Director, Cinchona Department
Mr. K. N. Raghavan Nair	...	Scientific Officer, M/s. Kanan Devan Hills Produce Co.
Dr. K. C. Naik	...	Vice Chancellor of the University of Agricultural Sciences, Bangalore
Mr. C. P. Natarajan	...	C. F. T. R. I., Mysore
Mr. S. Subramaniam	...	Deputy Director, I S. I., Madras

UPASI SCIENTIFIC DEPARTMENT

Dr. K. S. Venkataramani	...	Director
Dr. C. S. Venkata Ram	...	Deputy Director
Dr. G. N. Rao	...	Entomologist
Mr. V. Ranganathan	...	Chemist
Mr. T. S. Padmanabhan	...	Advisory Officer
Mr. R. Padmanaban	...	Advisory Officer
Mr. P. Jayasurya	...	Advisory Officer
Mr. P. Swaminathan	...	Research Assistant in Chemistry
Mr. H. Subramanian	...	Research Assistant in Entomology
Mr. C. P. Devasahayam Joseph	...	Research Assistant in Plant Pathology
Dr. (Mrs.) S. Kanthamani	...	Biochemist

INTRODUCTORY REMARKS

by Mr. N. Bhagwandas

President, UPASI

I take pleasure in welcoming you to the Sixteenth Scientific Conference. The scientific conference has become so popular in recent years that we are now contemplating a conference of this nature for the benefit of our coffee members. Being myself a planter and one who has been attending the conference without interruption for the last many years, I found the conference a convenient meeting forum between our Scientific Department and the tea membership in general.

Dr. Venkataramani, our Director, has chosen the theme of this year's conference with great care. This gives us an opportunity of reviewing the progress we have achieved during the last 25 years in the field of tea research. The deliberation of this conference, I am sure, will also pave the way for acquainting ourselves with the nature and kind of activity that our Scientific Department might be called upon to do during the years to come.

I would now request Mr. D. A. Cook, Chairman of our Tea Product Sub-Committee to take the Chair and conduct the proceedings.

CHAIRMAN'S WELCOME ADDRESS

D. A. Cook

Ladies & Gentlemen :

First it is my duty to thank our President for inaugurating the Sixteenth Conference of the UPASI Scientific Department, and to welcome our distinguished guests, and indeed all those present today, who are equally distinguished, in their own spheres. They certainly look distinguished, all dressed in their smart suits, anyway.

This is an appropriate occasion to pay tribute to the memory of Mr. S. Ananda Rau, who was a distinguished Chief Scientific Officer of the UPASI, and was a familiar figure at these gatherings. We shall remember his services to the Scientific Department with gratitude.

At the time of the Budget Meetings, when a reduction of Re. 1/- per hectare was effected in the Research Section of the estimates, doubts were expressed, and fears raised, that some curtailment of the services rendered by the Scientific Department and even some reduction in staff, might take place. I hope you will agree that these fears have proved groundless, and that it is the same mixture as before. Whether or not the cut will have to be restored, either at the next Budget Meeting in March 1971 or even before, remains to be seen.

Our Advisory Service remains in embryo, mainly due to a difference of opinion between the Government of India and ourselves. We submitted our minimum requirements to develop the Advisory Service. The Government saw fit to cut it in half -which means that we could make no progress whatsoever - except by our own efforts. The debate continues; and we have not given up hope of getting our masters in Delhi - particularly the Financial Department - to see reason. Nevertheless, we have three Districts now under advice by our scientists, men trained to offer practical advice on the day to day problems facing the planters. Judging by their periodic reports submitted to the Tea Product Sub-Committee they are busy men, are appreciated and are performing a very useful service.

Meanwhile, our Scientific Department soldiers on, and I think you will agree that we are seeing and hearing more of them these days. If you feel you are not getting the service you require, I suggest you pay a visit to the Research Station, and complain on the spot. You will be interested, and I hope impressed, by what you see there. While Scientists, like Revenue Inspectors, are never satisfied, and never seem to conclude their research projects, their equipment has improved considerably, and my impression on a recent visit was that the current approach is thoroughly practical in every Department, with a bias toward the economic aspect of planting which is a vital point in these expensive, inflationary times.

We had hopes to be able to hear an address by Mr. A. K. Roy, Chairman of the Tea Board, today; but unfortunately for us, he is under transfer orders, and we have to start once again with our Advisory Service to a new Chairman. We can only wish Mr. Roy the best of luck in his new post in Rajasthan; and thank him for the understanding he accorded to the Industry's problems both in Research matters and in their wider aspect.

Our noble Director has decided on a propaganda exercise this year - lest we forget - and has made 25 years of Tea Research in South India his theme. I look forward to his account, which I am sure will emphasize the progress achieved; and indeed, indicate the huge strides made in scientific knowledge of the tea bush, its maladies and their cures, and its great potential.

I must welcome, in particular,

Mr. W. J. Grice and Mr. R. Choudhury of Tocklai Experimental Station in Assam,

Dr. W. M. W. B. Manipura and Dr. V. S. Kulasegaram of the Tea Research Institute of Ceylon,

Mr. R. L. Narasimhaswamy, Director of Research, Coffee Board,

Mr. M. Mohan Rao, Director of the Government Cinchona Department,

Mr. K. N. Raghavan Nair, Scientific Officer of the K. D. H. P. Co.,

Mr. C. P. Natarajan, our old friend from the Central Food Technological Research Institute, Mysore,

Mr. S Subramaniam, Deputy Director, I. S. I., Madras and

Dr. K. C. Naik, the distinguished Vice-Chancellor of the University of Agricultural Sciences, Bangalore,

and conclude by reiterating my pleasure at seeing such a large attendance today, and expressing the wish that you will be interested and educated by today's programme.

TWENTYFIVE YEARS OF TEA RESEARCH IN SOUTHERN INDIA

K. S. Venkataramani

It is my privilege to introduce the theme of today's conference, viz. 'Twentyfive years of tea research in southern India'. The object in choosing this subject is to review our work over several years and from our own angle it is good to take stock periodically of what we have done. The theme is vast, very vast indeed and the time at our disposal is rather short - only three hours this morning. It is impossible to review the entire work in such a short time and I have already presented a comprehensive review of tea research in southern India in our Annual Report for 1967–1968. We have, therefore, decided to present a few mini-lectures covering only some of the important aspects of tea research.

During the past twentyfive years our scientific department has faced several challenges, which have all been well met by the scientists. Our work and achievements are no mean contribution to tea research. Some of you might think that we are trying to blow our own trumpet. Even so it is, and we need not apologise for doing it.

You are no doubt aware of what the investment on tea research in southern India has been these several years. If you try to equate the results of research with the funds doled in, you will at once realise that you have reaped bumper harvests.

My colleagues will shortly tell you something of their work. But at this stage I must mention that we are always conscious of your problems and we give due weightage to cost structure of the cultural practices while designing our experiments and our recommendations are inevitably practical and economical.

With modest resources we have been able to contribute something substantial to the industry. For example:

(i) The method evolved by us for controlling *Helopeltis* by dusting with DDT has resulted in the economic running of tea estates in Central Travancore.

(ii) The potentialities of chemical control of blister blight were clearly brought out after laying field trials within a couple of years of the advent of the fell disease.

(iii) The use of colloidal copper with a low copper content and nickel chloride in the control of blister blight was first recommended by us.

(iv) We were again the first to prove the existence of physiologic races of the blister blight fungus and to explain why immunity to this disease should not be the prime criterion in a tea clonal selection programme

(v) The role of potassium in the nutrition of the tea bush was highlighted for the first time by this Department. We were able to prove conclusively that debility and defoliation (or premature leaf-fall) markedly noticed in tea bushes in mid-elevation estates in the late 1940s were due to potash deficiency.

(vi) We take credit for having sown the idea of using soil fumigants in the control of tea root diseases, although others might have made use of it and developed it further.

(vii) With the aid of field trials we were able to make firm recommendations on the use of dalapon for the control of grass weeds in tea fields. Similarly we were also able to advocate, as early as in 1962, the use of low rates of Gramoxone for the control of dicot weeds, thus effecting considerable economy in the usage of expensive chemical weedkillers.

(viii) Our investigations on mist-blowing of pesticides have shown how economic control of pests, preventing crop losses, could be achieved.

(ix) We have clearly shown that in most areas judicious foliar application of zinc sulphate boosts up the tea crop.

(x) We have also demonstrated how moribund tea bushes could be rejuvenated.

(xi) Our investigations on tea clonal selection and propagation have been most fruitful and we have released a few tea clones which are worthy of extended cultivation.

(xii) Our work on the chemistry of tea clones, though of an academic nature at present, is full of promise.

These findings and achievements, we believe, have had and will have far reaching consequences. I must add, however, that the application of the scientific method to the tea industry is a co-operative endeavour – co-operation between the planter and the scientist. It is futile to regard the scientist as a person dabbling in expensive experimentation with no surety of practical results. There can be no practical results without experimentation, which must often be expensive. May I end this introduction with the hopeful note that a real scientific atmosphere prevails in the tea plantation industry giving ample scope for further research and the much needed breakthrough which the industry expects of its scientists.

DISEASES AS LIMITING FACTOR IN TEA CROP PRODUCTION - WOOD ROT AND ZINC DEFICIENCY IN SOUTHERN INDIA

C. S. Venkata Ram

It is now well documented that the blister blight disease of tea causes annihilating losses in crop that are easily noticeable (Venkata Ram, 1969b). It is equally well known that root diseases wipe out the tea plants in small and large infected pockets. In sharp contrast to these diseases there are others whose occurrence on the tea bush is insidious, which covertly but adversely affect the economy of tea cultivation. Foremost of such diseases is 'wood rot' caused by the fungus *Hypoxylon serpens*, brief reports of which were published in the last few years (Venkata Ram. 1962, 1963, 1964, 1966, 1967, 1968a, 1969b). Closely following 'wood rot' is zinc deficiency, another widespread problem but whose occurrence in S. India as a disease of great economic importance is of relatively recent origin (Venkata Ram, 1967, 1968b, 1969a). The present paper aims at underscoring the magnitude of these two disease problems, focussing interest on how substantial crop gains can be achieved by the implementation of prompt control measures.

Wood rot: In 1935 this disease was reported from S. India for the first time as occurring on the aerial parts of the tea bush in the High Ranges and the Anamallais (Anonymous, 1935), rendering the affected parts dry, brittle and non-functional. The causal fungus was identified as *Hypoxylon vestitum* Petch. The name 'wood rot' is given to the disease because the affected tissue crumbles to a powder on gentle pressure. Following this early report, the next record of 'wood rot' was from some tea areas of Mysore and the Wynaad in 1962 (Venkata Ram, 1962), but the causal fungus was in this case identified as *Hypoxylon serpens* (Pers ex Fr) Kickx. The disease was later recorded in the tea areas of the Tirunelveli district (Venkata Ram, 1963), the Nilgiris (Venkata Ram, 1964) and in 1967 it was reported as the most important stem disease of tea in S. India (Venkata Ram, 1967). Examination of the 'wood rot' affected specimens from the various districts confirmed the identity of the pathogen as *Hypoxylon serpens*. The fungus is easily recognised from its fructifications which take the shape of irregular patches, dark grey or black in colour, slightly raised, more often measuring 0.5 to 3 cm. in length and breadth but sometimes exceeding 3 cm (Fig. 1), found either on the branches or on the main stem. That 'wood rot' occurs on an extremely severe scale in certain sections of the tea in the Anamallais became evident from a random survey carried out recently when it was observed that 60% of the bushes were attacked in one field One of the interesting findings on 'wood rot' was that the causal fungus occurs on 4-year old branches and that the disease is not confined only to the old wood. There is no doubt that the high incidence of the disease is due to failure to clean out the infection on the bushes while pruning.

'Wood rot' is essentially a stem disease, different from the Tarry Root Rot of tea in N. E. India attributed to *Hypoxylon asarcodes*. The occurrence of 'wood rot' is, in the majority of cases manifest by the typical fructification of the fungus (Fig. 1). At present very little information is available on the mode of entry of the causal parasite, but the evidence points to infection taking place through tissue on the stem which is affected by sun scorch. Viable ascospores, germinating readily in water, are discharged from the stromata bearing the perithecia and these are carried to fresh infection sites by meteoric rain. Once the fungus gains entry into the stem it spreads gradually within the branches, ultimately reaching the main stem. Observations made on the spread of the disease showed that the new shoots which developed, after pruning in May on the branches infected by *Hypoxylon serpens*, died in September. Often only one branch, or a portion

of the bush, which is affected by 'wood rot' dies but when the infection girdles the main stem the entire plant is killed. Chemical control of the disease is beset with difficulties of finding a fungicide that would penetrate several layers of plant tissue to eradicate the fungus *in situ*, hence the only recourse is surgery aimed at the removal of all infected tissue. Surgical treatment carried out at the time of pruning, an operation commonly termed 'selective pruning' or 'rejuvenation pruning', is curative and it gives dramatic results. It is gratuitous to mention that unless the tea bush has a healthy and vigorous frame, the plant will neither be fully productive nor will it be able to respond fully to good husbandry.

In 1966 advantage was taken of the widespread occurrence of 'wood rot' in one area at an elevation of 3,500 feet on the Anamallais, to study the response of the disease affected tea to rejuvenation pruning. The field in question was in the 6th year of its cycle, the bushes were scraggy and carried only a thin cross-section of maintenance foliage. The field had yielded a maximum crop of 2395 lb/acre in 1965 in the 12 months of the calendar year following the previous medium pruning in September/October 1960. Pruning for rejuvenation commenced in the third week of April 1966 after approximately 4 inches of rainfall was received and it continued until the end of May, i e., for the period of approximately 6 weeks. Considerable amount of the diseased wood had to be sawed off on almost all the bushes, in certain cases collar pruning being necessary. The average pruning height was around 6 inches. Wherever a hollow or a cavity had developed in the main stem, or on the large side branches, such depressions were filled with cement mortar. The large pruning cuts were painted with a slurry of 50% wettable copper oxychloride in raw linseed oil. Damossing was done with lime, applied with a hand brush. In October and November, 6 months after pruning, the shoots were tipped at 30 inches from the ground level. The crop recorded from the field in the four years after rejuvenation pruning, as also the previous cycle, is given in Fig.2.

Following rejuvenation pruning the field gave very high yields, a crop of 2880 lb/acre and 3080 lb/acre (estimated) being recorded in the fourth year of the cycle, from pruning and tipping, respectively. These high yields reflect the response of the healthy bushes to augmented levels of manure application, a response that was well above the maximum in the years when the frames were severely affected by 'wood rot'. Details of manure application are omitted as they do not bear directly on the problem, as long as the field received adequate levels of manure which it did. The crux of the observation is that the crops increased appreciably after the bush frames were rejuvenated.

Fig. 3 illustrates the results of a comparative study on crop harvested in the same field in three years following a medium and rejuvenation prune. The investigation was undertaken in an estate at an elevation of approximately 2900 feet in Central Travancore. Of the 16.51 acres of tea in the field, 2 acres were pruned for rejuvenation in the manner described earlier in this paper, while the remaining 14.51 acres were medium pruned at 24 inches height. Pruning was carried out in May 1967 and the crop, made tea per acre, recorded in each of the three years from September 1967 is given in Fig. 3. It is seen that in the first year the medium pruned tea yielded more than the rejuvenated section, obviously because the latter came into tipping about 12 weeks after the medium pruned section. In the second year the rejuvenated tea yielded more than the medium pruned tea, but the difference in crop was small. It was in the third year that the yield difference was most striking Whereas the crop increase in the rejuvenated tea was 1237 lb/acre in the third as compared to the second year of the cycle, in the case of the medium pruned tea the yield in the third year registered a drop (Fig. 3). In the third year the rejuvenated tea yielded 3443 lb/acre as compared to 1518 lb/acre of the medium

pruned tea and the crop figures for 3 years for the two sections were, respectively, 6405 and 4853 lb/acre. This represents a 32% increase for the rejuvenated tea and here it is interesting to refer to one of the very early reports of this department where a 20% loss due to canker on tea frames was mentioned (Shaw, 1927).

It should be emphasised that no 'wood rot' infected tissue should be allowed to remain on the affected bushes, since any portion of the stem harbouring the fungus will lead to further penetration of the pathogen into the bush frame and ultimately the infection will spread to the collar when it may not be possible to save the bush. At mid-and low-elevations the best time to undertake rejuvenation pruning is April/May, *before* the 'rush' crop is harvested, but only after roughly 4 inches of rainfall has been recorded in a 2 to 3 week period prior to pruning. If the pruning is done immediately after taking the 'rush' crop, it may result in die-back of a number of bushes. At high elevations where the tea plant carries a good cross-section of starch reserves all through the year, rejuvenation pruning should be done when injury to the frame from sunburn does not pose a threat. It is gratuitous to record here that adequate protection against the blister blight disease is essential for ensuring satisfactory recovery from rejuvenation pruning.

Zinc deficiency: It is well known that minor element deficiency can cause insidious losses in agricultural and horticultural crops. In the case of tea the first record of zinc deficiency was made in clonal nursery plants (Venkataramani, 1962) and whilst earlier observations did not indicate any serious situation with regard to zinc deficiency in S. India (Venkata Ram, 1963), recently symptoms of severe to acute deficiency were recorded in South Kerala, Wynaad, Mysore, Anamallais and Nilgiris (Venkata Ram, 1967, 1968a), very likely leading to crop stagnation. Zinc deficiency is now known to occur throughout the tea in S. India and the reasons for the sudden appearance of this disease have been discussed earlier (Venkata Ram, 1968b). The symptoms of zinc deficiency in tea are easily recognised by the characteristic malformation, brittleness and chlorosis of the leaves; typical leaf and shoot symptoms are illustrated in Fig. 4 which include sickle shaped, slightly chlorotic leaves (Fig. 4, B, C, D and G), shortening of the internode and bunchy appearance of the shoot (Fig 4, A and H). Following foliar application of zinc sulphate spray the deficiency symptoms disappear (Venkataramani, 1962) and in two experiments carried out (Venkata Ram, 1968a, 1969a) appreciable increase in crop was recorded. Table I summarises the results of a trial laid out in 1967, comparing the relative efficacy of different levels of zinc sulphate application as foliar spray, in single and split doses. Only the percentage increase in crop over the control, attributable to zinc foliar treatment, is given in Table I, as the actual figures for yield have appeared elsewhere (Venkata Ram, 1968a, 1969a). Details of the experimental layout are also omitted because they have been already published (Venkata Ram, 1968a). The yield from the plots under the seven zinc treatments and the control was very similar prior to the application of zinc sulphate foliar spray. Treatments were imposed in October 1967, in the case of treatments 4, 5, 6 and 7 they extended to November. In the first year, i.e., from October 1967 to September 1968, application of 2 lb/acre zinc sulphate five times at 15-day intervals gave a crop increase of 14.5% over the unsprayed control. This was the maximum increase and in this treatment the zinc salt was incorporated with the routine blister blight spray, hence there was no additional impost of cost of application. Crop increment ranged between 8.5% and 14.5% as a result of zinc foliar application over a yield of 2380 lb/acre made tea in the control, a substantial increase. The higher rate of usage of zinc sulphate, namely, 20 lb/acre, was inferior to the lower, 10 lb/acre, rate.

Table I

No.	Particulars of zinc sulphate foliar application							% increase over untreated		
	1967			1968	1969					
	lb/acre	x times	Interval	lb/acre	lb/acre	x times	Interval	1967-68	1968-69	1969-70
1.	10	1	—	5	—	—	—	12.6	5.0	4.4
2.	5	2	15-day	—	10	1	—	8.5	1.0	2.0
3.	10	2	15-day	—	10	1	—	11.4	—	5.5
4.	5	4	15-day	—	5	1	—	12.5	2.3	—
5.	2	5	15-day	—	2	5	15-day	14.5	4.0	12.1
6.	5	2	40-day	—	5	1	—	13.7	—	—
7.	10	2	40-day	—	10	2	40-day	9.1	1.0	9.0
Crop harvested in the untreated control, lb/acre								2380	2400	2670

Subjective evidence from other observations indicated that continual spraying with zinc sulphate in the second year when a dosage in excess of 20 lb/acre was applied, led to crop decline and the occurrence of a high percentage of dormant shoots on the bush. Hence, in 1968 only treatment 1 received 5 lb/acre zinc sulphate, in the other treatments no zinc was put out. The crop in the second year was higher than in the control by 4% and 5% in treatments 5 and 1, respectively; in three other treatments there was a slight increase and in two no increase (Table I). In October 1969 all the treatments excepting treatment 1 received zinc sulphate at levels and intervals given in Table 1. The 2670 lb/acre crop recorded in the control was for the period October 1969 to July 1970 and over this treatment 5 gave an increase of 12.1%. It was interesting to observe that application of 5 lb/acre in treatment 4 and 6 did not result in any crop increase, but the 10 lb/acre levels and the 20 lb/acre zinc sulphate applied in treatment 7 produced crop gains.

Translating the results to actual gains it is seen that with zinc sulphate foliar spray at 10 lb/acre, 2 lb applied 5 times at 15-day intervals, in alternate years, an yield of 8204 lb/acre made tea was recorded in 34 months, whereas in the untreated control which was cropping below its full efficiency owing to moderately severe zinc deficiency, the yield in the same period was 7450 lb/acre. All the zinc treatments gave increase over the unsprayed control and whilst the overall increase of annual crop was at a maximum of 14.5% in any one year, an increase of 23% was registered in a short 3 month period in 1968 (Venkata Ram, 1968a).

At present it is recommended that in all cases of moderately severe to severe zinc deficiency 10 lb/acre zinc sulphate be applied in alternate years incorporated with the fungicide spray that is used for blister blight control, 2 lb put out 5 times at 15-day intervals starting from September when the heavy South West monsoon rains have ceased. In areas which come under the North East monsoon, the zinc treatment could be carried out between October and the following January; full particulars of zinc application under different situations have already been published (Venkata Ram, 1968b). Whether application of zinc sulphate foliar spray annually is likely to be superior to application in alternate years is a subject now under study. The question is also under investigation as to the rate of usage of zinc sulphate in an annual spraying programme in case the latter is found beneficial as compared to zinc treatment in alternate years.

SUMMARY

1. 'Wood rot' caused by *Hypoxylon serpens* is a disease of the tea bush where only surgery aimed at eradicating the infection on the stem ensures rejuvenation of the frame with concomitant increase in crop. In one investigation a crop increase of 32% was recorded for the rejuvenated tea over medium pruned tea in a three year period.

2. Zinc deficiency has recently become an important limiting factor in tea production all over S India. Application of 10 lb/acre zinc sulphate incorporated with the usual fungicide spray put out for the control of blister blight gave upto 14.5% crop increase over one year and an increase of 23% in a 3-month period after the treatment was imposed. Results so far obtained indicate that the 10 lb/acre zinc sulphate is best applied split 5 times, 2 lb in 4 gallons of the fungicide spray fluid per acre on alternate weekly rounds, starting from early September. The treatment is to be repeated in alternate years.

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Explanation of Figures

Fig. 1. Shows typical fructifications of *Hypoxylon serpens* on 'wood rot' affected tea stem.

Fig. 2. Shows the crop harvested in each of the years of the cycle prior to rejuvenation pruning (thin broken lines) and after rejuvenation pruning. Thick solid line represents crop harvested from pruning, thick broken lines from tipping.

Fig. 3. Shows crop harvested in each year of the cycle from medium pruned compared to rejuvenation pruned section of tea in the same field; the first group of histograms indicate crop recorded in the previous pruning cycle.

Fig. 4. Symptoms of zinc deficiency: A and H, shortening of internodes giving the shoot a bunchy appearance; B, C, D and G, typical sickle shaped leaves; E and F, normal tea shoots.

Fig. 1

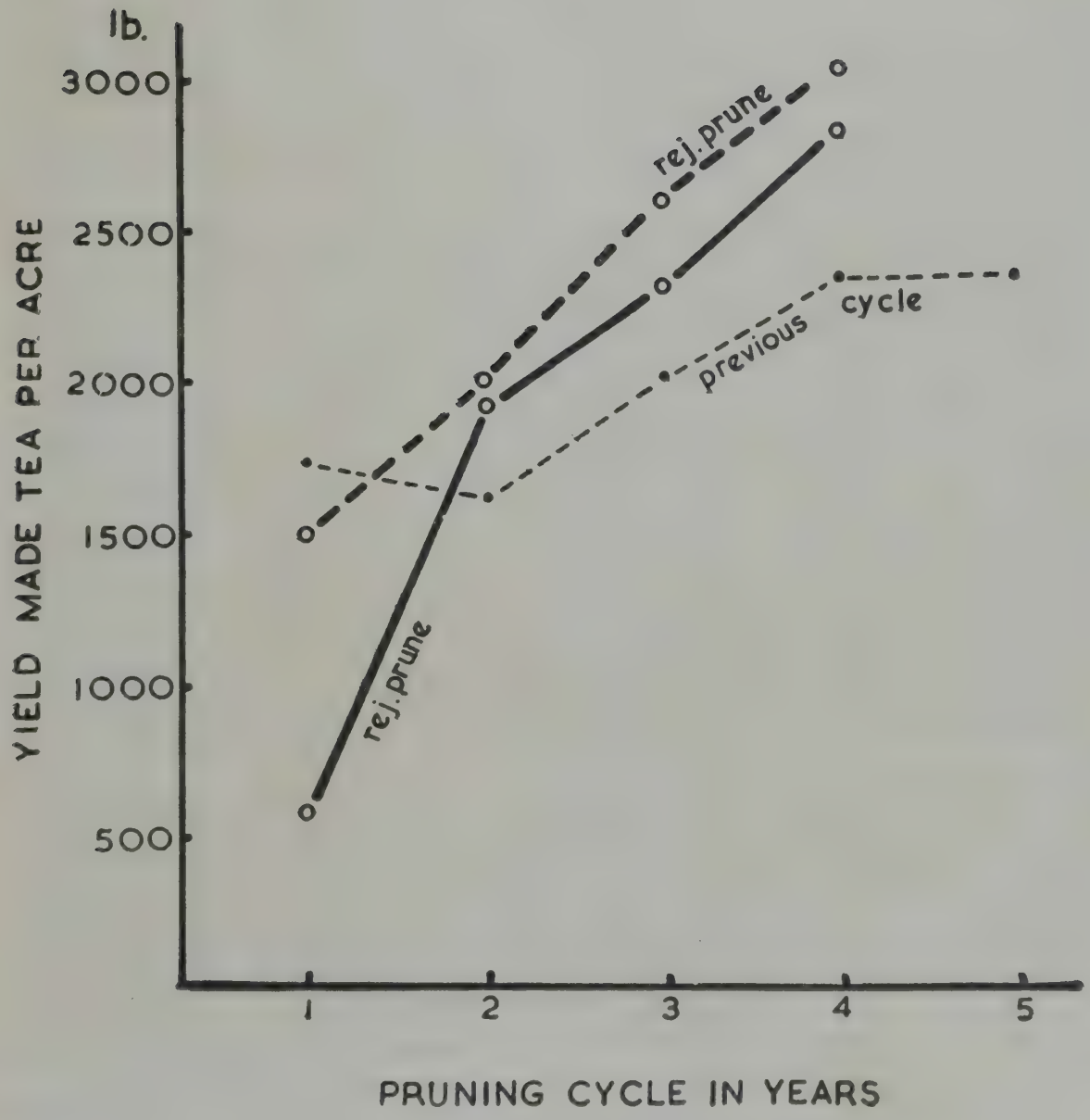
lb.
3000
2500
2000
1500
1000
500
YIELD MADE TEA PER ACRE
rej. prune
previous cycle
rej. prune
1
2
3
4
5
PRUNING CYCLE IN YEARS

Fig. 2

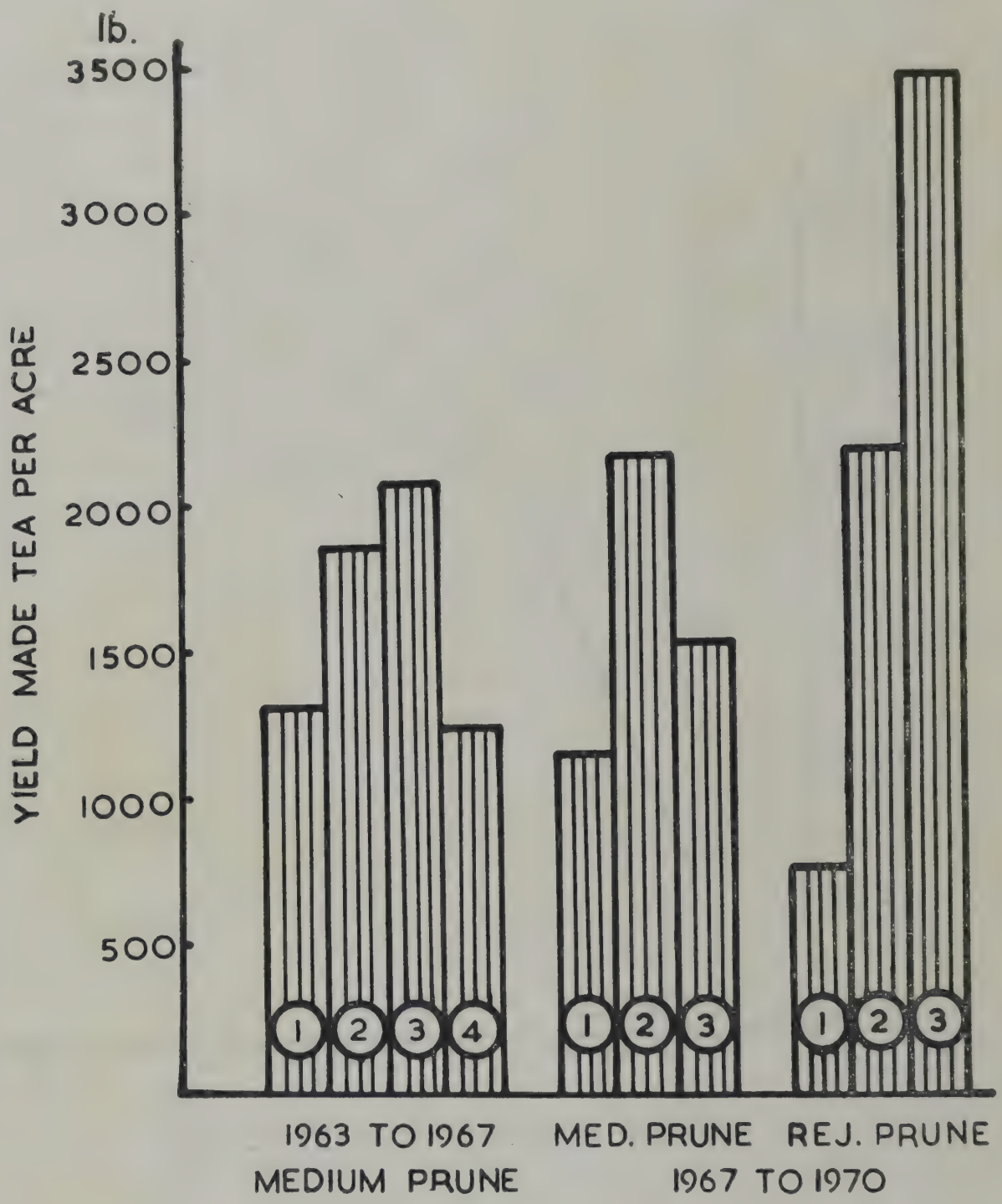
lb.
3500
3000
2500
2000
1500
1000
500
YIELD MADE TEA PER ACRE
1
2
3
4
1
2
3
1
2
3
1963 TO 1967
MEDIUM PRUNE
MED. PRUNE
1967 TO 1970
REJ. PRUNE

Fig. 3

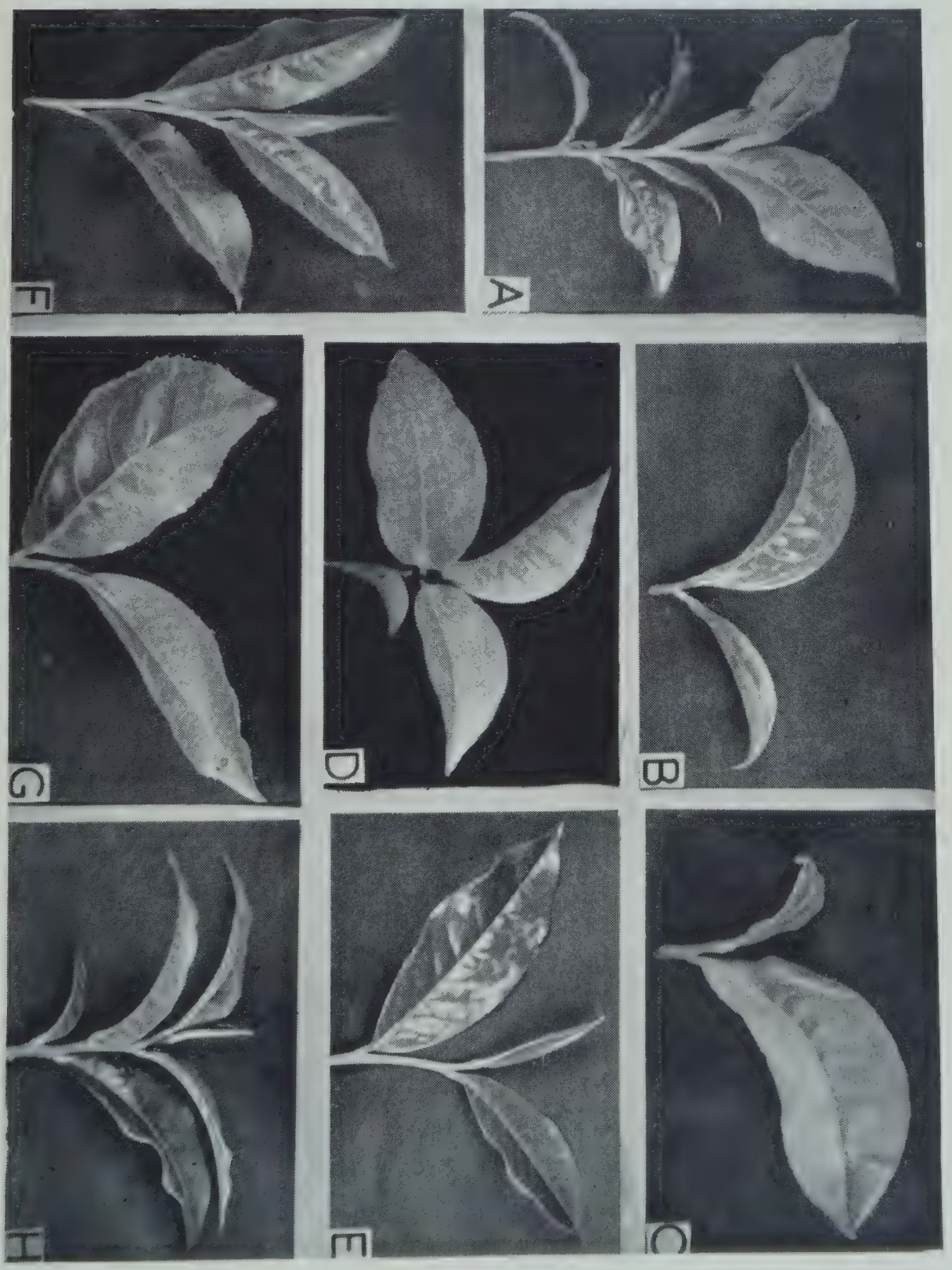

Fig. 4

POTASSIUM, A MASTER NUTRIENT FOR TEA

Y. Ranganathan

I would like to tell you something today about the role of potassium in tea nutrition. We recognised the importance of this plant nutrient over 20 years ago (4, 5). Our manurial experiment carried out at Devarshola from 1940-1953 has very clearly brought out the need for not only adequate potassium application but also the balanced application of potassium in relation to nitrogen (Fig. 1).

Too much or too little of nitrogen or potassium in relation to the other is harmful insofar as the crop yield is concerned (6). Our findings have now been confirmed by workers in other tea growing areas.

Potassium is an important osmotic regulator and that is why tea bushes suffer more in the drought when starved of this nutrient than otherwise. The first stage of deficiency of potassium is, of course, the gradual reduction in yield — an attempt of the bush to adjust itself to the low availability of this nutrient. This stage is not easily recognizable as the seasonal variations in yield are superimposed on this variation. We have eliminated the seasonal variations by per cent yield concept and have shown in Fig. 2 how the yielding capacity of the plots, which did not receive any potash, decreased from the 1st year to the 13th year of the experiment.

In plots receiving adequate potassium the yielding capacity of the bushes was either maintained at a level or it showed a slight improvement. When plants cannot reduce their yields further, deficiency symptoms occur. In tea, the sequence of appearance of symptoms is as follows: (1) Pronounced marginal scorch on many of the mature leaves, (2) premature leaf fall, leaving a crown of young foliage at the top, (3) development of thin and twiggy wood suggesting a debilitated condition, (4) absence of new flush growth, poor recovery after pruning and (5) ultimate death of the bushes creating vacancies in the field.

The slowness of the process leading to ultimate mortality is well illustrated in Fig. 3. Only after the 9th year the rate of mortality was high and during the last 4 years, the bush population dropped from 91 to 53 per cent in the plots not receiving potassium.

Is it worthwhile to wait till the deficiency symptoms appear and start applying potassium? The answer is an emphatic 'no'. Venkataramani (8) has shown that in a tea field which was suspected to be deficient in potassium tea bushes responded to application of potash and that the debilitated bushes could be nursed back to health provided the debility was not too advanced and that foliar application of potash was more effective in restoring the bushes to normalcy than soil application. The effectiveness of foliar application of potassium salts can be seen from the increase in the girth of the stems observed within a year of treatment (Fig. 4).

If the deficiency is far advanced, it may not then be possible to bring back the bushes to the normal condition. Therefore, application of adequate quantities of potassium every year is a must. We have always stressed on the importance of potassium and have recommended potash application at the rate of 4 lb. for every 100 lb of made tea till recently. Based on our present knowledge of the available potassium status of our tea soils we have now revised our earlier recommendation and are now suggesting the use of increased quantities of this nutrient.

Having recognised the importance of potassium for tea under South Indian conditions, we went a step further to study the various aspects of potassium availability and factors affecting utilisation of this nutrient by tea. Can we increase the soil potassium status by applying very large quantities of potash? The answer is 'no' because (1) tea soils have a low nutrient holding capacity (Table 1) and cannot retain large amounts of potassium.

Table 1: Nutrient holding capacity of tea soils.

District	Per cent soil under categories					
	Surface Soil 0-9″			Sub-Soil 9-18″		
	V. Low	Low	Medium	V. Low	Low	Medium
Anamallais	19	81	—	50	50	—
C. Travancore	—	90	10	—	100	—
High Range	—	100	—	20	80	—
Nilgiris	8	92	—	—	100	—
Malabar Wynaad	25	75	—	not available		
Nilgiri Wynaad	—	20	80	—	38	62
Average	22	65	33	14	74	12

V. low — less than 5 meq per cent
low — 5-10 meq per cent
medium — Above 10 meq per cent

(2) tea soils are acidic (Table 2) and hence potassium is weakly held and is liable to be removed by percolating and run-off water,

Table 2: Acidity status of South Indian tea soils

District	Per cent soil under categories					
	Surface Soil 0–9″			Sub-Soil 9-18″		
	E. A.	S. A.	M. A.	E. A.	S. A.	M. A.
Anamallais	74	26	—	83	17	—
C. Travancore	64	32	4	34	66	—
Coorg	50	50	—	25	75	—
High Range	69	31	—	62	15	23
Malabar Wynaad	100	—	—	not available		
Nilgiris	78	22	—	79	16	5
Nilgiri Wynaad	87	13	—	94	6	—
Tirunelveli	89	11	—	50	50	—
Average	71	29	—	61	35	4

E. A. — Extremely acidic; pH less than 5.0
S. A. — Strongly acidic; pH 5.1 –6 0
M. A. — Mildly acidic; pH above 6.0

(3) the kaolinitic clay minerals which predominantly occur in tea soils do not retain potassium strongly, (4) Very high and ill-distributed rainfall leaches out potassium which is not strongly held in soils for reasons listed above, (5) the enormous increase in the use of nitrogenous fertilisers has increased the acidity of tea soils (Fig 5) leading to greater losses of potassium. Moreover a large amount of nitrogen depresses potassium availability by a phenomenon well known as ionic antagonism, and (6) plants have the ability to remove potassium in quantities more than their actual requirement and hence there is very little residual effect of high potassium application, especially in a crop like tea in which new flush is being constantly removed.

One may, therefore, realise how difficult it is to build up the potash status of acidic tea soils under South Indian conditions. This is well brought out by our recent survey of the potash status of our tea soils (Table 3).

Table 3: Available potassium status of South Indian tea soils

District	Per cent soil under categories					
	Surface Soil 0–9″			Sub-Soil 9–18″		
	Low	Medium	High	Low	Medium	High
Anamallais	23	71	6	65	32	3
C. Travancore	9	82	9		not available	
Coorg	63	37	—	63	37	—
High Range	—	100	—	31	62	—
Malabar Wynaad	25	75	—		not available	
Nilgiris	41	53	6	47	53	—
Nilgiri Wynaad	44	56	—	78	22	—
Tirunelveli	96	4	—	90	10	—
Average	41	57	2	58	36	6

Low — less than 100 ppm

Medium — 100–300 ppm

High — Above 300 ppm

Inspite of liberal use of potash by many of our estates, the available potash status is still low or bordering low/medium categories.

Tea unlike other dicots controls carbon dioxide assimilation and synthesis of carbohydrates through a mechanism involving silicon. These plants, called silicon accumulators or calcium excluders have a high demand for potassium to run the synthesis of carbohydrates efficiently (1). This is one of the reasons for poor recovery after pruning commonly observed in tea bushes starved of potassium We have also evidence to show that tea is able to utilize potassium only from the soil solution and hence it requires a high level of exchangeable potassium for efficient absorption of this nutrient. We were, therefore, naturally led to investigate how the tea plants are able to meet their large requirement of potassium from soils inherently low in potassium. The cation exchange capacity of tea roots is lower than that of other dicots (Table 4) and, therefore, tea roots are able to selectively exclude calcium and absorb more of potassium from the soil solution.

Table 4: Root cation exchange capacity

Dicots	10 to 70 meq/100 g dry roots	Reference 2
Monocots	5 to 30 „	
Tea (Fields)	12 to 25 „	
Tea (Nursery)	18 to 35 „	

Another problem which often poses in relation to potassium availability is liming. If the pH value of the soil is very low, say below 4.8, which soils in most of the estates are now recording as a result of increased nitrogen application in recent years potassium is leached to a great extent. Under such conditions the soil tilth is also adversely affected leading to poor utilization of nutrients. We, therefore, recommend soil amendment with lime application in order to bring the soil pH to around 5.0. Some fear is now and then expressed on the possible adverse effect of calcium on potassium availability. This may be so under certain set of conditions, but we need have no such misapprehension under our conditions. The amount of calcium which we recommend is sufficient only to bring the soil pH to about 5.0 and at this level calcium will not affect potassium availability. We do agree, however, that liming will have a detrimental effect if our soils are only very slightly acidic, say with a pH value of 5.5 or more.

Critical examination of our earlier trials has indicated that it is possible to evaluate the nutrient requirement on the basis of soil tests (7). I shall deal with this subject in another paper to be presented this morning. With regard to tissue analysis relating to potassium, Jayaraman and Venkataramani have shown how important leaf sampling is and that analysis of the mature leaf above the fish leaf gives a better index of the potash status of the plant than analysis of the flush samples. Other scientists (3,9) have used the tender flush for analysis, but we do not agree with this for important reasons. The flush can indicate potassium deficiency only in extreme cases of malnutrition; in the initial stages of potassium deficiency it will fail to show any difference in its potassium status compared to that of a flush of a healthy plant – the flush can draw its requirement of potassium from the older mature leaves Our recent experiments have confirmed the findings of our colleagues. We also now find that the first two internodes (stem portion) below the first leaf may even prove to be a more useful guide than the mature leaf in predicting the potassium status of the plant, especially when the potash content is expressed on moisture basis and not on dry weight basis. In fields well supplied with potash, tissue potassium index is above 0.30 throughout the year. In fields where potassium is known to limit crop yields, it falls below 0.30 especially during 'rush' periods. Hence during the rush, the yields are lower in potassium deficient fields than in fields well supplied with potassium. Table 5 presents some of our observations.

Table 5: Potassium Index for Tea

Soil potassium status	Potassium (K_2O) content in					
	FLUSH			INTERNODES **		
	June '68	Feb. '69	May '69	June '68	Feb. '69	May '69
Sufficient	1.64	1.35	1.65	0.36	0.33	0.32
Deficient	1.65	1.31	1.62	0.29	0.36*	0.30
Deficient	—	1.76	1.43	—	0.34	0.26

* After additional potassium application

** Potassium (K_2O) on moisture basis.

Work on tissue analysis is being continued and in a year or two we may be in a position to make recommendations on potash applications based on plant analysis.

To sum up, our recommendations are :

1. Improve the retention of potash for a prolonged period in the soil by (a) increasing the soil organic matter status wherever it is low as this enhances the nutrient holding capacity of the soil, and (b) liming the soil wherever the pH is below 5.0.

2. Prevent as far as possible the loss of potassium by (a) applying the potassium in two split doses, one pre-monsoon and the other post-monsoon, and (b) placing the potassium at about 6" depth.

3. Make more potassium available to the plants by (a) controlling weeds which are heavy competitors for potassium : grasses in particular with their low root cation exchange capacity readily utilise most of the exchangeable potassium and reduce the availability of this nutrient to the tea plant, and (b) placement of at least part of the potassium applied; this helps in the greater rate of uptake from localized high concentration pockets and also enables the plant to absorb potassium from moist sub-soil, when surface soils are desiccated in the dry weather.

4. Apply balanced dose of potassium : Taking into consideration the yielding capacity of the bushes and the available potassium status of the soil our recommendation is as follows :

MINIMUM N:K RATIO RECOMMENDED

	Low K fields	Medium K fields
Low yielding field	2 : 1	2 : 1
High yielding field	2 : 1	5 : 2

N. B. Wherever there is additional stress on the utilization of potassium by plants created by excess acidity, low degree of potassium saturation, previous high yields, exceptionally high rainfall etc , the ratio may be temporarily fixed at 2 : 1 irrespective of soil potassium content.

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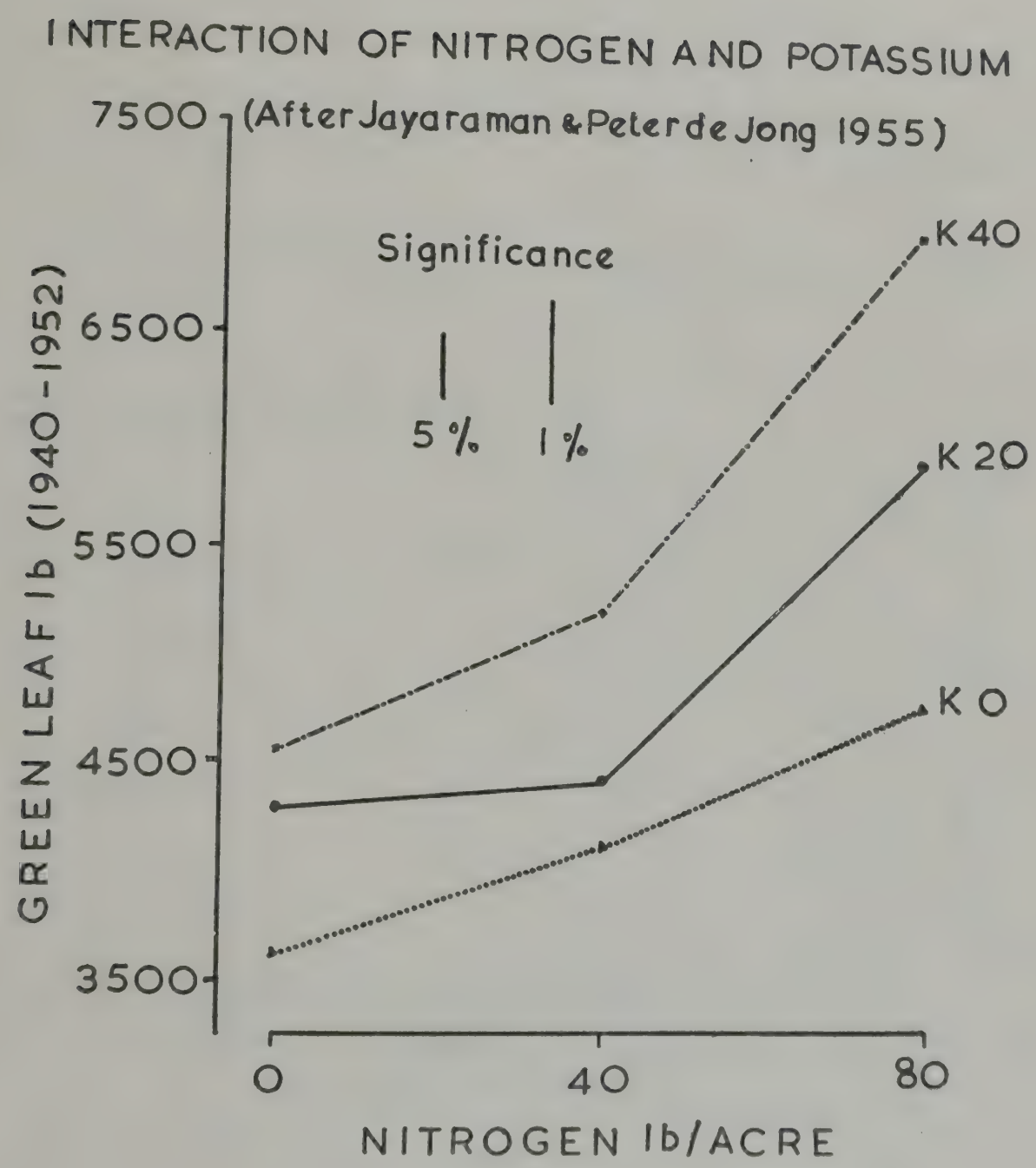
INTERACTION OF NITROGEN AND POTASSIUM
(After Jayaraman & Peter de Jong 1955)
Significance
5 %
1 %
K 40
K 20
K 0
GREEN LEAF lb (1940-1952)
7500
6500
5500
4500
3500
0
40
80
NITROGEN lb/ACRE

Fig. 1

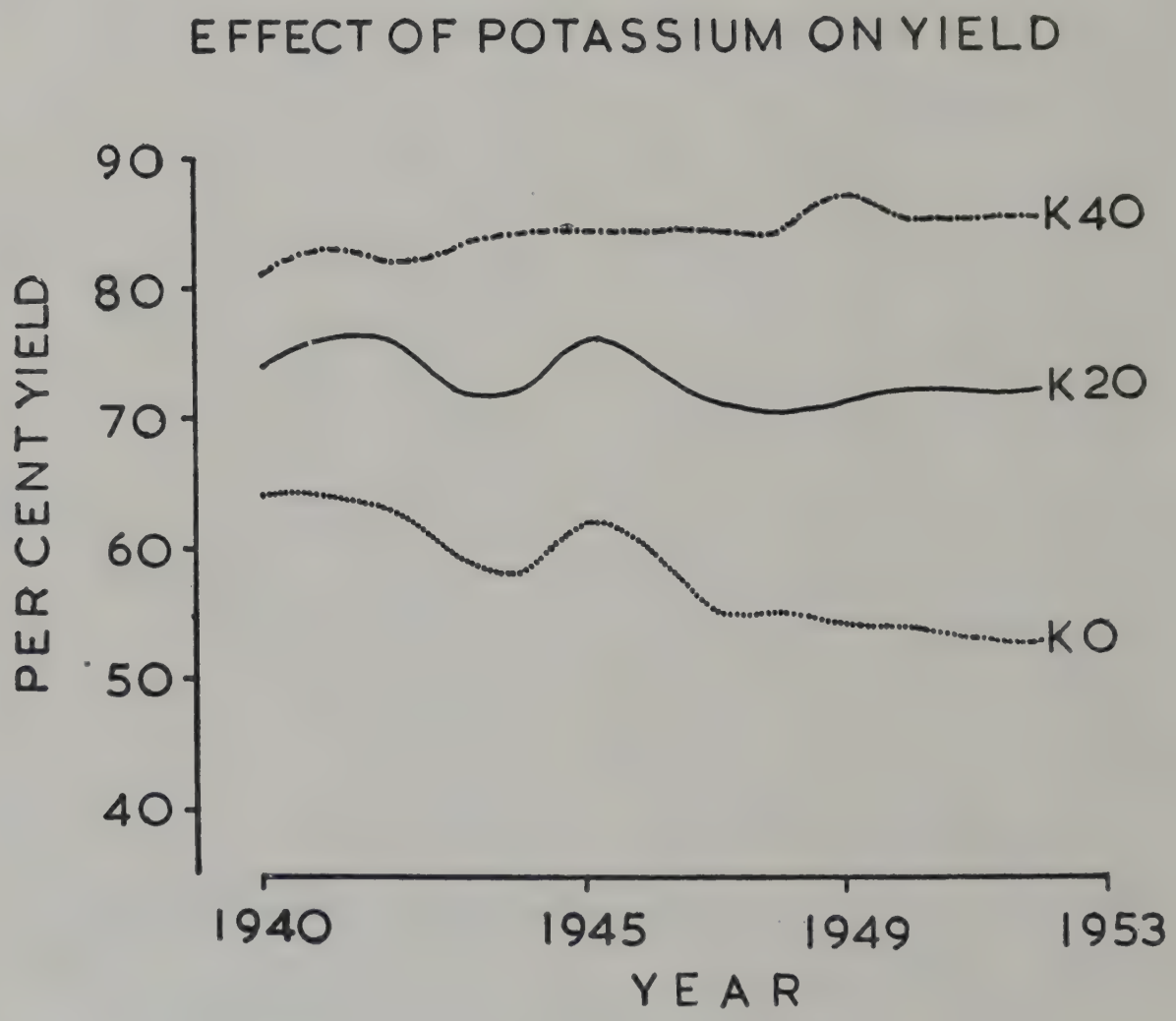
EFFECT OF POTASSIUM ON YIELD
PER CENT YIELD
90
80
70
60
50
40
K40
K20
KO
1940
1945
1949
1953
YEAR

Fig. 2

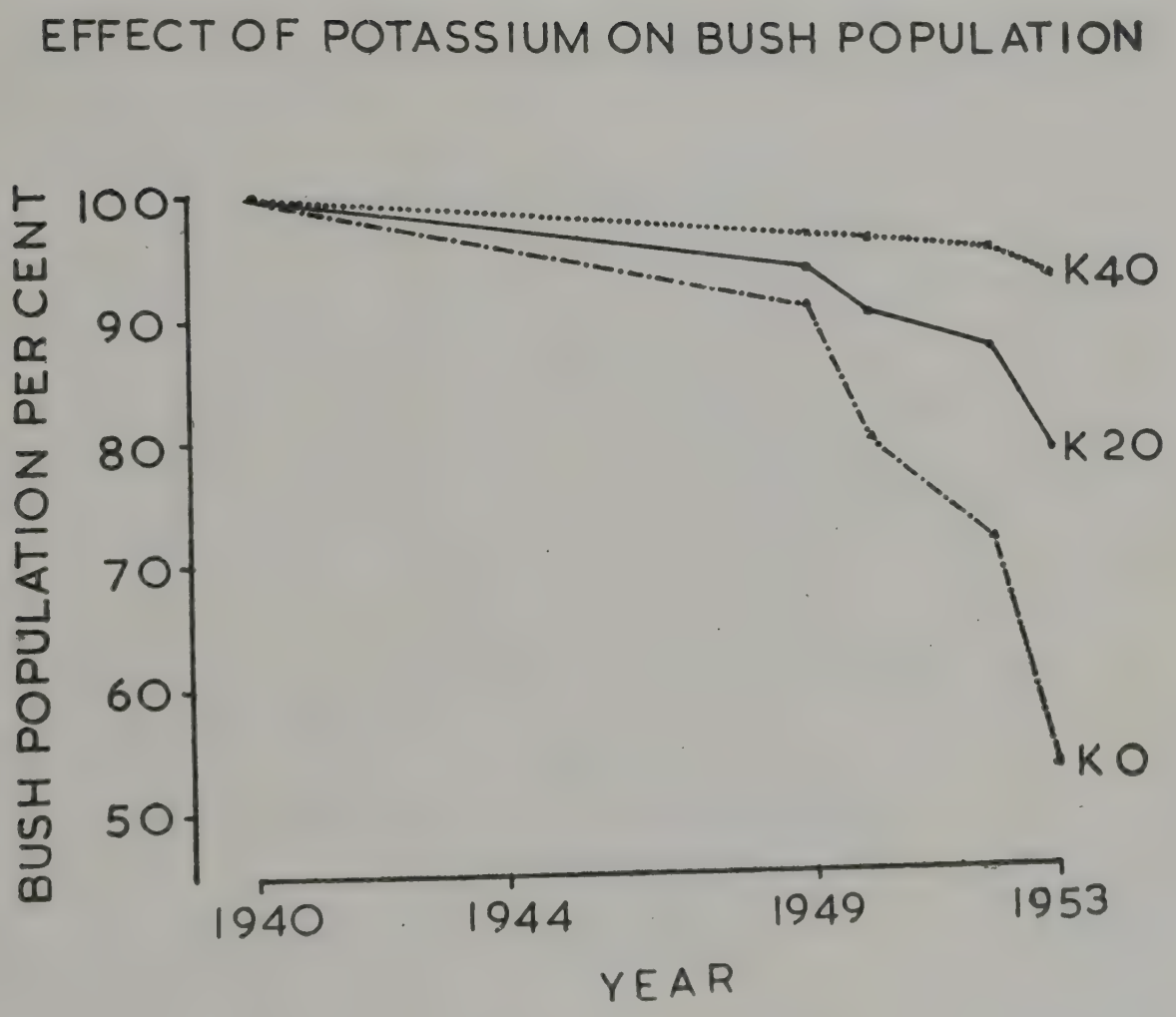
EFFECT OF POTASSIUM ON BUSH POPULATION
BUSH POPULATION PER CENT
100
90
80
70
60
50
K40
K 20
K O
1940
1944
1949
1953
YEAR

Fig. 3

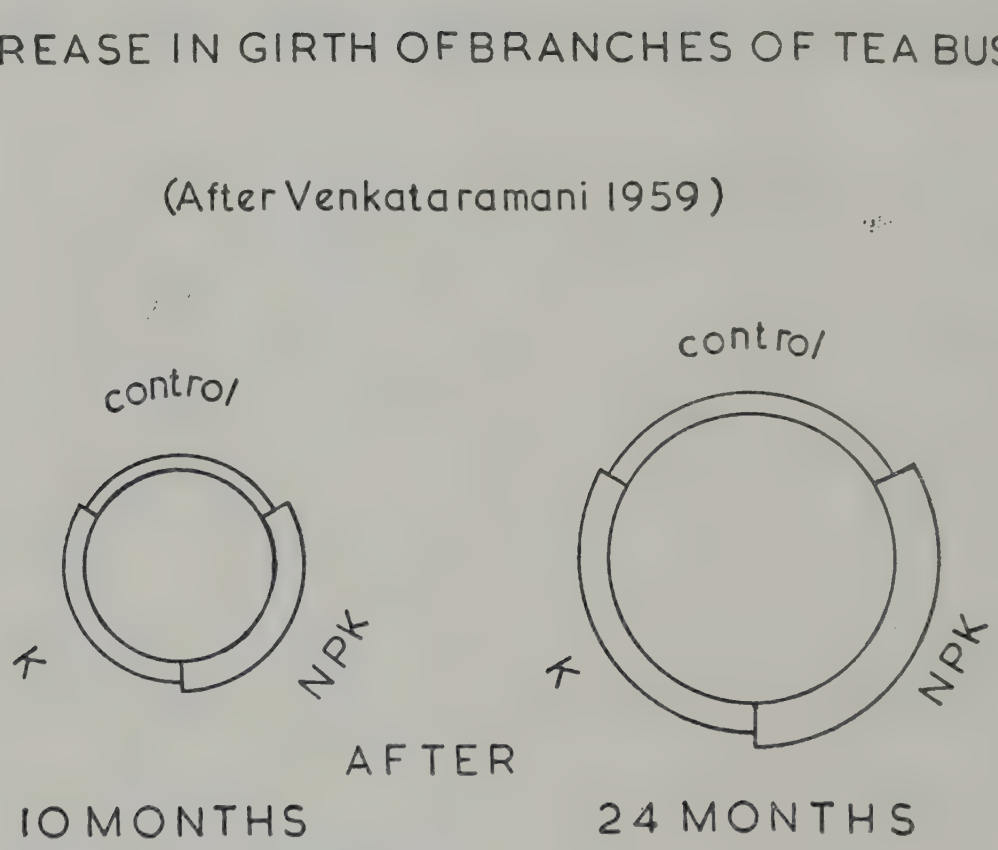
INCREASE IN GIRTH OF BRANCHES OF TEA BUSHES
(After Venkataramani 1959)
control
K
NPK
AFTER
10 MONTHS
control
K
NPK
24 MONTHS

Fig. 4

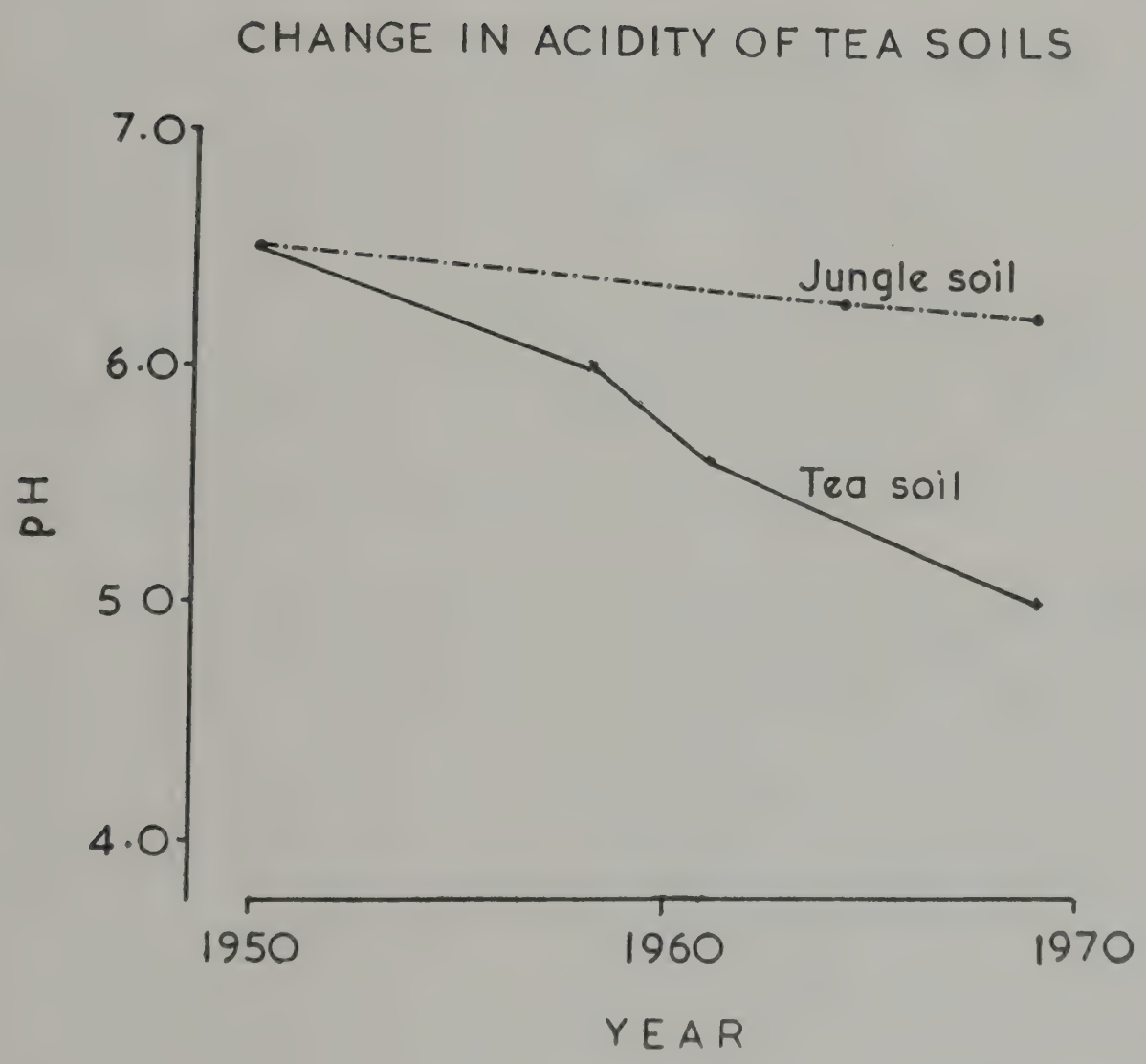
CHANGE IN ACIDITY OF TEA SOILS
7.0
6.0
5.0
4.0
pH
Jungle soil
Tea soil
1950
1960
1970
YEAR

Fig. 5

HELOPELTIS: A BREAK-THROUGH IN ITS CONTROL

G. N. Rao

The insect *Helopeltis*, popularly known as the tea mosquito bug, actually belongs to the group of sucking insects of the family Capsidae and has nothing to do with mosquitoes of any type.

It was first noticed in tea in Cachar about the year 1865 and one company alone was said to have lost about 50,000 lbs of tea in 1865 and 1867 due to *Helopeltis* attack.

It would appear that the insect was first noted in Java as early as in 1847 (Shaw, 1928). In 1884 Dr. Trimen recorded *Helopeltis* as a pest of Cocoa and Cinchona in Ceylon (Shaw, 1928). Although no definite records are available, in S. India the pest appears to have been causing serious damage in S. Travancore for about 50 years prior to 1940. Reports from Vandiperiyar district indicate that serious notice of the pest was taken only since about 1920. It may on the whole be stated that South and Central Travancore suffered the greatest damage due to *Helopeltis*.

It is generally admitted that *Helopeltis* is present in tea throughout the year, though at particular seasons its activities become more serious, resulting in economic losses. The seasonal prevalence of the pest is largely dependent on climatic conditions and there can be no doubt that *Helopeltis* is a wet weather pest, the insect being intolerant to very dry conditions (Ananda Rau, 1940).

Generally speaking, in the past, around 40,000 acres of tea in S. India were annually subject to the ravages of *Helopeltis* attack.

Helopeltis damage is of two kinds: (1) a direct loss of crop due to pluckable leaf and shoots being damaged and rendered useless; and (2) acute debilitation of the bushes leading to die-back and delayed and meagre flushing thereafter which account for poor yields following a severe attack. An idea of the crop losses due to *Helopeltis* in areas where it was known to be a serious pest could be had from Table 1.

Table 1

Locality	Per cent Loss of Crop	
	During the season	Over the whole year
S. Travancore	40-50	20-25
Venture Valley	20-40	10-20
Ranni Valley	25-100	4-40
C. Travancore	11-30	3-15
Mundakayam	40-60	10-15

Records maintained by the Department during the period 1941-48 (Table 2) give a reasonably accurate estimate of losses due to *Helopeltis* on an estate in Central Travancore (Manning, 1947).

Table 2

Year	Estimated loss of crop due to Helopeltis	
	Total made tea	Made tea per acre
1941—42	1,47,800 lb.	143 lb
1942—43	62,100 lb.	60 lb.
1943—44	27.550 lb.	27 lb.
1944—45	57,900 lb.	56 lb.
1945—46	1.71,500 lb.	166 lb.
1946—47	1,71,700 lb.	166 lb.
1947—48	2,60,500 lb.	250 lb.

In S. India in addition to tea, the following plants are also known to be attacked by *Helopeltis*: Cinchona, Cashew, *Bixa orellana*, Cocoa, *Cinnamomum camphora*, *Erythrina*, *Melia azadirachta*, *Swietenia*, *Tephrosia*, Guava, *Maesa*, *Polygonum*, Jack, Jasminum, ornamental *Camellias*, red gum, coffee, *Bidens pilosa*, morning glory, sweet potato, mango, *Passiflora* and probably many others.

The damage is caused by both adults and nymphs which are active during the early hours of the morning and late afternoons. When the sun is hot, they seek shelter in shaded and sheltered areas under the bushes. They suck up the sap from the young leaves, buds and tender stems with their sucking mouth parts: while doing so they inject toxic saliva which causes the breakdown of the surrounding tissues. Growth is severely affected and in extreme cases there is die-back of shoots resulting in 'crows feet'.

Looking back into the records of tea pests in S. India over a period of years prior to the forties, it would become quite obvious that barring *Helopeltis* in Central and S. Travancore, no other insect had assumed the status of a devastating pest and it naturally kept the Scientific Department occupied ever since its very inception (Ananda Rau, 1956).

Prior to 1940, few chemicals were available for economic control of the pest on a field scale. The department did not lose sight of the cultural aspect of the problem, viz. keeping fields free of weeds, light plucking, tipping and pruning. But these have only resulted in temporary alleviation, as they were mainly calculated to assist the bushes to withstand the attack. After a long period of lull, with the discovery of DDT during the second world war, the department lost no time in initiating trials with DDT for the control of *Helopeltis*. Soon the Department evolved a simple and cheap method of formulating DDT dust and with the introduction and use of DDT for the control of *Helopeltis* there was such a complete change in the picture, that within a few years tea estates previously afflicted by this menace had started harvesting all time record crops. It was estimated in 1948, the year in which large scale DDT dusting was taken up, that if the entire area affected by *Helopeltis* in Central Travancore came under treatment, it might well result in an increased production of the order of 4 to 5 million pounds of tea, as against an estimated expenditure of Rs. 5 lakhs for controlling the pest. In subsequent years, the production of tea actually did exceed the above estimate.

While all this increase cannot admittedly be attributed to *Helopeltis* control alone, it has however to be conceded that not an inconsiderable part of this increase in production was due to *Helopeltis* control with DDT.

In 1946 trials were first initiated with BHC and later with DDT. Soon it was found that dusting with BHC not only reduced the intensity of attack (Table 3 & 5) but also increased the yields (Table 4) and did not cause any phytotoxicity (Ananda Rau, 1947) yet the beneficial effects wore off rather quickly and BHC was also found to taint the tea, whereas with DDT (dust or spray form) there was no tainting of tea. At the same time there was no phytotoxicity; improvement in yields (Table 7 & 9) as well as considerable reduction in the intensity of attack (Table 6 & 8) were also recorded. Another experiment undertaken in 1947 with 5% DDT dust gave an increased yield of 1210 lbs green leaf over the control in 6 months (Table 9), which more than repaid the cost of chemical and dusting. DDT whether applied in dust form or as wet spray, was found to have a remarkable effect in bringing back to normal flushing condition bushes which had died back as a result of successive severe attacks of *Helopeltis*. The 1947 trials confirmed that crop response was spectacular and that DDT dusting aided rapid recovery of 'die back' bushes in a most striking manner.

Further trials carried out in 1948 indicated that BHC whether as dust or wet spray was inferior to DDT in the control of *Helopeltis* (Table 10 & 11).

By 1950-51, DDT dusting became more or less a routine practice on estates in Central and S. Travancore with the result that the pest ceased to be one of much concern, *Helopeltis* control by dusting with 4% DDT dust having proved eminently satisfactory. It was believed that a crop increase of the order of 100 lbs made tea/acre was registered in Central Travancore consequent on the control of *Helopeltis* with DDT.

As regards cost of treatments, the schedule of applications and timings originally recommended envisaged an expenditure of about Rs. 25/- per acre for the whole season for three rounds of dusting of a 4 or 5% DDT dust at 25 lbs/acre in April/May and September/October.

Although ready to use DDT dusts of the strength mentioned above were available in the market, the cost (Rs. 70/- per cwt) was considered too prohibitive and the Department soon produced a 'home made' equally effective dust formulation at about less than half the cost (Rs. 30/- per cwt), using 50% DDT dust, china clay as filler and gum acacia as sticker (Manning, 1948). The 'home made' insecticide developed was a 3% dust the formula being 6 lbs. DDT 50% dust, 93½ lbs. China clay, 1½ lbs. Gum acacia.

In the initial stages it was feared that mixing the ingredients might pose a problem, as only a 'home made' improvised mixing machine could be rigged up for the purpose. But, soon the mixing technique was so very well perfected that the resulting product when put to several tests, was found to be as effective as if not better than, the commercially available dusts.

Thus the discovery of a cheap and effective method of control of *Helopeltis* with DDT can be said to be one of the outstanding contributions made by the Scientific Department.

Although reports of *Helopeltis* damage do come in occasionally even today, it is seen that the damage is confined to a few odd chronic patches in some estates

in Central and South Travancore. This could be partly due to the pest developing resistance to DDT; but we have reason to believe that it is more due to inadequate control resulting from faulty dusting or spraying than resistance to DDT.

In recent years we have tried the following chemicals for the control of *Helopeltis* and found them to be quite useful (Rao, 1967): Thiodan @ 1 : 1000; Trithion @ 1 : 1000; Dee Dee Tol @ 1 : 250; Murfotox @ 1 : 1000 and Ethion @ 1 : 1000. Of these only Ethion has been cleard by the US FDA.

The following compounds are also likely to be useful against *Helopeltis*; Anthio @ 1 : 500; Azodrin @ 1 : 1000; Kilval and Zolone @ 1 : 1000.

Once again we wish to point out that the technique of dusting or spraying is very important and unless the job is done thoroughly and efficiently no useful purpose can be served.

It is only in the fitness of things that we should express our gratefulness to the late Mr. Ananda Rau for the extensive work done by him on the control of *Helopeltis*. In fact the present paper deals with his contributions towards the effective control of this pest.

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Table 3

Effect of BHC treatment on Helopeltis attack

Treatment	Intensity of Helopeltis attack (%)					
	May			June		
	*15	22	29	7**	14	24
BHC Dust	20	5	28	48	22	59
Control	21	17	37	56	57	69

* pretreatment count

** second application given soon after this operation

Table 4

Effect of BHC treatment on yield

Treatment	Yield in lbs green leaf					Total
	June				July	
	7	14	24	29	16	
BHC Dust	77	59	57	13	6	212
Control	61	34	18	4	5	122

Table 5

Effect of BHC dusting on Helopeltis attack

Treatment	May			June		
	15	22	29	7	14	24
BHC (1% Dust)						
(a) % free shoots	63	91	46	17	51	3
(b) no. of pluckable shoots	222	237	246	221	217	144
Control :						
(a) % free shoots	61	65	27	10	16	2
(b) no. of pluckable shoots	232	236	248	187	154	28

Table 6

Effect of treatment with DDT on intensity of Helopeltis attack

Treatment (DDT)	Intensity of attack (percentage)		
	1st plucking 5—10—46	2nd plucking 14—10—46	3rd plucking 22 10—46
Spray	20.1	7.7**	21.5*
Dust	21.8	2.6**	19.1*
Control	21.1	24.6	35.0

* significant ** highly significant

Table 7

Effect of DDT treatments on yield of tea

Treatment (DDT)	Yield in lbs. green leaf				
	PLUCKING				
	1st	2nd	3rd	4th	5th
	October 1946 Date				Nov. 1946
	5th	14th	22nd	31st	9th
Spray	21	74	143**	197	137
Dust	16	73	164**	252	196
Control	28	80	73	66	46

** highly significant

Table 8

Efficacy of DDT in reducing Helopeltis damage in tea shoots

Treatment	Percentage healthy shoots		
	PLUCKING		
	1st	2nd	3rd
Spray	45.4	79.3**	49.2*
Dust	42.2	92.3**	52.3*
Control	36.1	46.3	28.5

* significant ** highly significant

Table 9
Improvement in crop yields following DDT treatment

Treatment	Crop (lbs/ac.) green leaf in 6 months
DDT 5% dust – 6 applications @ 23 lb/ac.	2061
Control	851

Table 10
Comparative efficacy of DDT and BHC treatments against Helopeltis attack

Treatment (spray)	No. of bushes attacked out of 2400 in each treatment					
	Dec. 25	Jan. 3	11	17	24	31
DDT 1%	5	5	15	8	5	11
BHC 1%	148	338	478	399	282	211
Control	1068	1139	1117	921	812	634

Table 11
Comparative efficacy of DDT and BHC treatments against Helopeltis attack

Treatment (spray)	No. of shoots attacked out of 800 at each plucking before and after spraying					
	Dec. 15	22	30	Jan. 7	18	28
DDT 1%	157	94	2	7	5	6
BHC 1%	164	107	78	92	75	62
Control	139	143	221	213	164	132

* Before spraying

DISCUSSION

CHAIRMAN : What results have you achieved in Ceylon from rejuvenation of tea ?

DR MANIPURA : We have laid out some observation trials in Ceylon and the results of these trials are awaited. But generally on estates the frames of tea bush are hard pruned only when it is essential.

DR. VENKATA RAM : In Ceylon 'wood rot' caused by the fungus *Hypoxylon serpens* does not exist, therefore the problem of diseased bush frame does not have the same magnitude as it does in South India. I would like to know from Mr. Grice the situation in N. E India.

MR. GRICE : We have no 'wood rot' problem, but we do notice quite a bit of 'thorny stem blight' in the Darjeeling area and *Poria* on the plains. We recommend replanting of tea on the plains when the frames are badly disease affected and in Darjeeling we recommend rejuvenation pruning.

MR. ANSARI : What is the best time for rejuvenation pruning at mid-elevations ?

DR. VENKATA RAM : The best period is April when the bush reserves are high but it should be started only after a few good showers are received. Rejuvenation pruning can be done in August also, but if the root starch reserves are low at that time 'lungs' will have to be left to ensure recovery.

A MEMBER : What about the danger from exposure to severe blister blight if rejuvenation pruning is done in April because the bushes will be recovering at the peak of the blister season.

DR. VENKATA RAM : Well, blister blight has to be controlled and this is none too difficult a task.

DR. VENKATARAMANI : Apart from proper timing that is required for rejuvenation pruning, it is equally important that the new frame that develops is made strong and vigorous by special manure application. We recommend application of a 1 : 1 : 2 NPK mixture with the nitrogen levels ranging from 60 to 80 pounds per acre.

DR. VENKATA RAM : These recommendations have already been printed in our article on 'rejuvenation pruning' in the Planters' Chronicle.

CHEMICAL WEED CONTROL IN TEA

K. S. Venkataramani

Are weeds harmful to the tea crop? Should weed growth in tea fields be controlled and if so how best could their control be achieved economically? These are some of the questions with which a practical planter is often posed. Let us examine briefly the problem of weed control in tea fields.

Without entering into a discussion we may baldly state that weeds do suppress the crop (5, 6, 7, 8, 10, 14, 38). Weeds have been accused of 'stealing' the fertilizer and, of course, they do so, if they are removed from the field. But should they be retained in the field, either in growth or decay, they do not unduly interfere with the response of the fertilizer on a long range basis. In clearings, however, they compete with the young tea plants for nutrients, and also for moisture at least during certain periods of the year. With grass weeds, it has been shown that they markedly retard the growth of young tea plants (30). Weeds also influence the micro-climate and disease incidence, as in the case of the blister blight disease of tea. An uncontrolled weed growth is also a nuisance to the workers. It is little wonder, therefore, that weeds have been ruthlessly condemned and weed control has become a routine practice in tea culture.

The usual methods of weed control in plantation crops involve the employment of manual labour for pulling out the weed and the use of cutting, digging and scraping implements, and also thatching and mulching whenever and wherever possible. These are the methods followed not only in this country, but all over the tropics (2).

Digging and scraping lead to much soil disturbance and possibly also erosion and root injury, the effect of which may even be worse than the presence of weeds. It is also now recognized that in most tea areas vigorous cultivation of the soil as such is an unnecessary practice.

The traditional method of weed control, which is nothing more than an ever recurring drudgery, has now become rather expensive. Apart from expense, the availability of labour at the appropriate time also poses a problem. This naturally raises the question whether there is any other method of approach to the problem of weed control than persuading, cajoling and enticing – since sterner methods are no longer respectable or legitimate – our labour forces to continue to pull them up with the roots at more or less regular intervals? Chemical weed control at once comes to the mind.

The use of chemicals for weed control is by no means new, but it has received impetus only during the past twenty-five years. Extensive investigations on chemical weed control are being made all over the world and far reaching achievements have been obtained in this field of research. Fifteen years ago chemical weed control was relatively undeveloped in the plantation industry, in general, but for the last ten years now such a control measure has become a regular feature in rubber culture in Malaya (1).

The potentialities of chemical weed control in tea have been indicated already by a few workers (4, 13, 33). For the past twenty years we have been testing the available weedkillers (18 to 37) with the aim of finding out whether, in these days of rising labour costs, we would soon reach a stage when we could confidently expect one man with a knapsack sprayer to replace the weeding gang

with an assortment of tools such as the fork, sickle and mammoty. This stage has now been reached and simultaneously chemical weed control has also come into vogue in tea plantations.

Our observations and the results of our investigations have been published already in our annual reports and bulletins. We shall now summarize these results in this paper.

Control of grass weeds :

Why should we control grass weeds in tea? The answer is simple. They suppress growth of the tea plants, and their effect is markedly noticed in clearings even within a short time. The growth of young tea is retarded in the presence of grasses (Plate 1; Table 1).

Table 1: Effect of grass on growth of young tea plants (1961)

Components	Dry weight of plants in mg		Sig. Diff. P = 0.05
	Control series	Grass series	
Internodal stem and mother leaf	362	289	65.5
New leaf and stem	2107	817	481.3
Total aerial portion	2469	1106	544.1
Roots	845	338	265.1

Of the few weedkillers tried, formulations based on dalapon (2, 2 dichloro propionic acid) have given promising results in the control of grasses in tea fields. Our trials have shown that in general, two or three applications of dalapon at the rate of 5.6 kg/ha (5 lb/ac.) are superior to one application of 17 kg ha. (15 lb/ac.). This finding is in consonance with that of other workers in other crops (11, 18). No visible phytotoxic symptoms developed in tea and we have also not observed any crop depressing effect, provided the dosage of dalapon did not exceed 5.6 kg/ha at any one application.

This chemical may persist for several weeks in cold and dry soils, but in warm and moist soils its breakdown, as a result of microbial activity, takes place rapidly and it disappears almost completely within four weeks (16, 17). This significant feature, together with ready absorption and translocation of the chemical through living grass foliage makes it comparatively a safe weedkiller formulation for use. If the applications are timed properly and if excessive drenching of the soil is prevented, dalapon may not prove a hazard to the tea crop. In fact, it is sufficient if the grass foliage is wetted thoroughly with the weedkiller solution and there is no necessity to drench the soil with the chemical. Further trials have shown that two applications of dalapon, each at 5.6 kg/ha., or better still three applications, the first at the rate of 5.6 kg/ha. and the next two at 3.36 kg/ha. (3 lb ac.) in a convenient volume of water would give a reasonable control of grass weeds.

The grass weed problem is greatest in the clearings and in mature tea during the first two years of the pruning cycle. If grasses are kept under check during this period with a total of three or four applications of dalapon, properly timed and applied, that should normally be sufficient. With the development of a good cover of tea in subsequent years weed growth will naturally be suppressed and no further chemical application may be required. We repeat that proper timing and follow up of applications are necessary and the importance of this has already been emphasized (26).

Soon after the grass is killed it can be noticed that there is an invasion of broad leaf weed flora. In our experiments at Devarshola, two weed species, viz. *Borreria ocymoides* and *Centella asiatica*, were the dominant ones. These two weeds grew so quickly and profusely that no other weed had a chance to establish itself. This would show that if the aim is to eradicate grass, its control must be followed by the sowing of a smother crop, for example a cover crop (*Mimosa invisa*) whereever possible, or encouraging the development of some harmless dicot weeds which could be readily kept under check.

Dalapon may kill young dadaps (*Erythrina lithosperma*), wattles (*Acacia* spp.) and silver oak (*Grevillea robusta*), if they are inadvertently sprayed. If the spray application is immediately followed by a heavy rain, leaching the chemical into the soil, some defoliation of older dadaps may take place, but the trees will soon refoliate and recover (Plate 2). We would, therefore, once again emphasize the importance of the timing of the weedkiller application.

The results of our experiments are presented in the following tables and it could be seen that in almost all cases, weedkiller treatments have resulted in pushing up the yields (Tables 2, 3, 4).

Table 2: Control of grass weed with dalapon (1960-1961)

Treatments	Green leaf in kg. from 800 bushes in 11 months	% increase
Slash weeded	1430.3	—
Dalapon 5.6 kg. per hectare, 2 applications	1570.6	9
Dalapon 5.6 kg. + 3.36 kg /ac.	1475.0	3

Table 3: Control of grass weeds with dalapon (1960-1961)

Treatments	Green leaf from 250 bushes (11 months)	% increase
Slash weeded	366 kg.	—
Hand weeded	375 kg.	2.4
Dalapon 5.6 kg./ha, 2 applications	387 kg.	5.8
Dalapon 5.6 + 3.36 kg./ha.	389 kg.	6.0

Table 4: Control of grass in tea fields (1962-1963)

Treatments	Green leaf in kg. from 150 bushes in 13 months	% increase or decrease
Estate practice (slashing)	155	...
Untreated	137	— 11 6
Digging	159	+ 2.6
Dalapon (4 + 2 + 2 lb./ac.)	166	+ 7.1
Gramoxone ($\frac{1}{2}$ 1 x 4 applns.)	163	+ 5.2

It is clearly seen that if grass weeds are allowed to grow unchecked, tea yield is suppressed and that digging and removal of grass is only very slightly better than slash weeding (Tables 2 and 4). In all experiments where grasses were controlled with dalapon, perceptible yield increases were obtained.

Control of broad leaf weeds:

Species of broad leaf weeds (dicots) commonly confronted in our tea fields are too numerous to mention here. They have been listed in our Annual Report for 1967–1968. Most of these weeds could be kept under control and they should not be regarded as harmful. But the creepers like the climbing hempweed (*Mikania scandens*) and Morning Glory (*Ipomoea* species) form a class by themselves and they should on no account be encouraged in tea fields. We shall not refer to their control in this paper, but we would like to add that so far 2, 4-D formulations have been found to be the best in eradicating them.

The chemical weedkillers currently available are all useful in controlling the common broad leaf weeds. Our field trials carried out during the period 1961 to 1963 with seven different formulations have shown the possibility of using some of them safely in tea fields. The results obtained with three formulations are summarised in Tables 5 and 6.

Table 5: Control of dicot weeds (1961-1963) — weed density in experimental plots

Treatment	Fresh weight of weeds in kg. per 3 sq. m.	Average score
Slash weeding	4.384	100
2, 4-D	0.088	15
Gramoxone	0.848	25
Simazine	1.488	30

Very good control of weeds was obtained with 2, 4-D, Gramoxone and Simazine as can be readily gauged from the weed density data presented in Table 5.

Table 6: Control of dicot weeds (1961–1963)

Treatments	Green leaf from 400 bushes			
	Feb. 62 — March 63		April — Oct. 63	
	kg	+%	kg	+%
Estate practice (slashing)	439	...	243	...
2, 4-D	457	4.1	273	12.3
Gramoxone	457	4.1	271	11.5
Simazine	466	6.1	267	9.9

Yield increases in the range of 9 to 12 per cent were obtained by keeping the weeds under good control.

Simazine when applied at the rate of 2.23 to 3.36 kg/ha (2 to 3 lb/ac) at each application in about 560 litres of water per hectare (about 50 gal/ac) gave adequate control of most weeds, except perennial grasses, for a period ranging from 3 to 4 months. As this chemical acts through the soil as a pre-emergence weedkiller it is obligatory that it is applied to a clean weeded field. Ordinarily the chemical remains in the top 2.5 to 5 cm. (1 to 2 inches) of soil and acts in this region. Timing of application is, therefore, important. The best time is when at least 50 to 75 mm (2 to 3 inches) of rain are expected to follow the weedkiller application. From theoretical considerations, the two possible times of application in most of our tea areas are: (i) the end of the dry period, i.e., the period just prior to the onset of the S. W. monsoon rains, and (ii) the break in the rains, especially the period between the S. W. and N. E. monsoon rains – in other words April/May and September/October. Later experiments have shown that the dosage could be reduced to 1 to 1¼ kg/ha per application, but three applications properly timed, were required to achieve adequate control of weeds.

2, 4-D formulations, particularly the sodium salt and amine salt, were found quite useful in controlling broad leaf weeds. When applied at the rate of 1 lb. of active ingredient per acre in 40 to 50 gallons, a very good control of most dicot weeds was obtained. Repeat applications were, however, necessary and three sprays were sufficient to keep the fields reasonably clean of weeds. Three years continuous use of 2, 4-D formulations in tea fields, did not exert any adverse effect on the tea bushes.

Gramoxone was another formulation which gave excellent control of broad leaf weeds in our experiments. Everyone is now familiar with this weedkiller and it would suffice to add that considerable economy in its use could be effected, if the weedkiller application is properly organised. In the first application, a dosage of 0.7 litre in about 340 litres of water per hectare (½ pint/30 gal./ac) is all that may be required and it could be readily reduced to half this volume if careful follow up

sprayings are done. With the use of a proper sprayer low pressure knapsack such as Bakpak, Plasto) fitted with the right kind of nozzle (C4 or 024 flood-jets) and properly trained spray gangs who can go round at frequent intervals and spot spray young succulent weeds, it is today the cheapest weedkiller available for safe use in tea fields.

Another weedkiller of promise is Karmex (Diuron) and preliminary experiments have shown that dosage rates of ½ to ¾ kg per hectare will be required to obtain good control of most weeds in tea fields. Two applications may have to be made.

All our experiments in tea and those carried out in other crops almost all over have shown that no one weedkiller can really do the job of controlling weeds in crop lands. Weeds resistant or tolerant to one weedkiller readily develop following the continual use of a particular weedkiller. This is all too familiar to tea planters using Gramoxone extensively. It has, therefore, become a general practice to apply combined sprays (or cocktails) of two or three weedkiller formulations; for example, Gramoxone and 2,4-D or Gramoxone, 2,4-D and Karmex, or Dalapon and 2,4-D. Various combinations may be used and experience shows that with such combined sprays considerable saving could be effected in the quantities of the weedkiller formulations put out. We shall deal with this subject in another publication.

Conclusion

It is accepted that uncontrolled weed growth suppresses the cropping of the tea bush to a greater or lesser extent (10, 14). A loss of crop of about 9 per cent over three years due to soft weed competition was recorded in one of the experiments in Ceylon (8), and our observations in small scale trials have shown losses in the range of 6 to 12 per cent within the first two years of the weed control trials. Weeds, in general, and grasses in particular, are known to affect the availability of nitrate nitrogen and potash to crop plants (3, 10) and according to Glover (10) it has been determined in Assam that under a thick cover of thatch *(Imperata cylindrica)* the soil nitrate content is about 0.1 part per million parts of soil of the top 22.5 cm. (9 in.) as compared to 5 to 10 parts per million in clean soil between tea bushes. Is the loss in crop in a weedy field due to this factor or are other factors also involved? Plant ecologists have observed that weeds have an adverse effect on the growth of roots of crop plants growing in their vicinity. To quote Salisbury (15), the Canadian botanist Pavlychenko who made some quantitative observations on this aspect found that a single oat plant grown completely free from weeds developed so many and extensive roots that if these were joined as a continuous thread its length would be fifty miles. When weeds were allowed to grow around the oat plant the total length of that root system was reduced to about a quarter mile. In other words, weeds reduced it to a two-hundredth part of the extent of what it was with competition absent. In a short term trial with comparable tea clonal plants we found that a living grass cover over the soil adversely affected the growth of young tea plants; the growth of roots was markedly retarded, the plants under grass producing 60 per cent less of roots, as determined by their dry weight, than those in weed free soil (30). Little wonder that crop yields are adversely affected under weedy conditions. Apart from suppression of crop, weeds have other undesirable effects as has already been mentioned in the introduction and therefore they should be kept under check.

Why have weeds become troublesome in a tea field? What are the factors which influence their uncontrolled growth in a perennial crop like tea? Are not the

traditional methods sufficient to keep weeds under control? Should we resort to chemical treatment, or should we aim at a balance between both? These several questions at once come to mind and let us try to examine them briefly.

Weeds pose a real problem only in the clearings and in mature fields during the first year of the pruning cycle - and perhaps in some cases in the second year also. In open situations, with poor or no shade grass weeds become prominent. With the advent of the blister blight disease and with the unfortunate removal or drastic reduction of shade to combat the disease opportunities for increased weed growth have arisen. Hard pruning and bad plucking, and adverse effects of pests and diseases reduce the size of the bush and thereby permit more exposed soil to be available for the invasion of weeds. With lighter pruning and improved spread of bushes, and with close planting and quick cover of the field, the problem of weeds will be reduced considerably. Thatching and mulching in the clearings play an important part in weed control in young tea until the tea plants themselves are well developed and cover the ground. Mere disturbance of the soil only encourages dormant seeds to sprout, and in the case of grasses it is not uncommon to find that the more one digs, the more the grass grows. It has been estimated that the non-removal of only 1 per cent of the existing roots of couch grass *(Digitaria scalarum)*, in the course of eight weeks, leads to no less than 30 per cent reinfestation of the weeded area, and where follow up operations are delayed, the field gets as grassy as before (9). What do these mean to us? Aren't they pointers to the fact that good husbandry in itself is partly an answer to the problem of weed control?

With rising labour costs there is no doubt that we should find a cheap and effective substitute or alternative to manual labour for weed control. Our trials, as well as those of others elsewhere have shown that most of the weeds commonly occurring in tea fields at all elevations could be tackled with three or four readily available weedkillers. Our emphasis is on judicious use of these chemicals. Weedkillers are not tools that can be used thoughtlessly and if they are used in the wrong way they can do much harm; they should be regarded as tools of the good husbandman to be integrated into the crop production programme from the very start (12, 39). We would like to emphasize again that no one chemical can successfully do the job of controlling all weeds in tea fields. Weeds resistant to one chemical may develop with continual use of a particular weedkiller and this, indeed, has occurred and every tea planter who has used Gramoxone knows that such weeds as species of *Borreria*, *Exallage*, *Polygonum*, *Calceolaria*, *Centella* and others have become the predominant members of the weed flora of fields treated with that weedkiller. Such situations, however, are not insuperable and we know that combined sprays of Gramoxone and 2, 4-D or Gramoxone and Karmex are useful in overcoming such difficulties. In ending, we would like to add that successful use of a weedkiller presupposes on the part of the user knowledge of the action of the chemical that is being used and capacity to judge the correct timing of application and to combine the chemical treatment with the normal cultural methods.

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Explanation of Plates 1 and 2

Plate 1:	Fig. 1.	Young clonal tea plant growing in a grass infested soil.
	Fig. 2.	Young clonal tea plant in a clean weeded soil.
Plate 2:	Fig. 1.	A healthy dadap tree in full foliage in an untreated plot.
	Fig. 2.	A partially defoliated dadap tree in a plot treated with Dowpon at the rate of 5 lb. per acre.
	Fig. 3.	A fully defoliated dadap tree in a plot treated with Dowpon at the rate of 10 lb. per acre.
	Fig. 4. and Fig. 5.	Grass weeds in untreated tea field.
	Fig. 6. and Fig. 7.	Broad leaf weeds growing in a tea field after the grass has been killed with Dowpon.

Plate 1

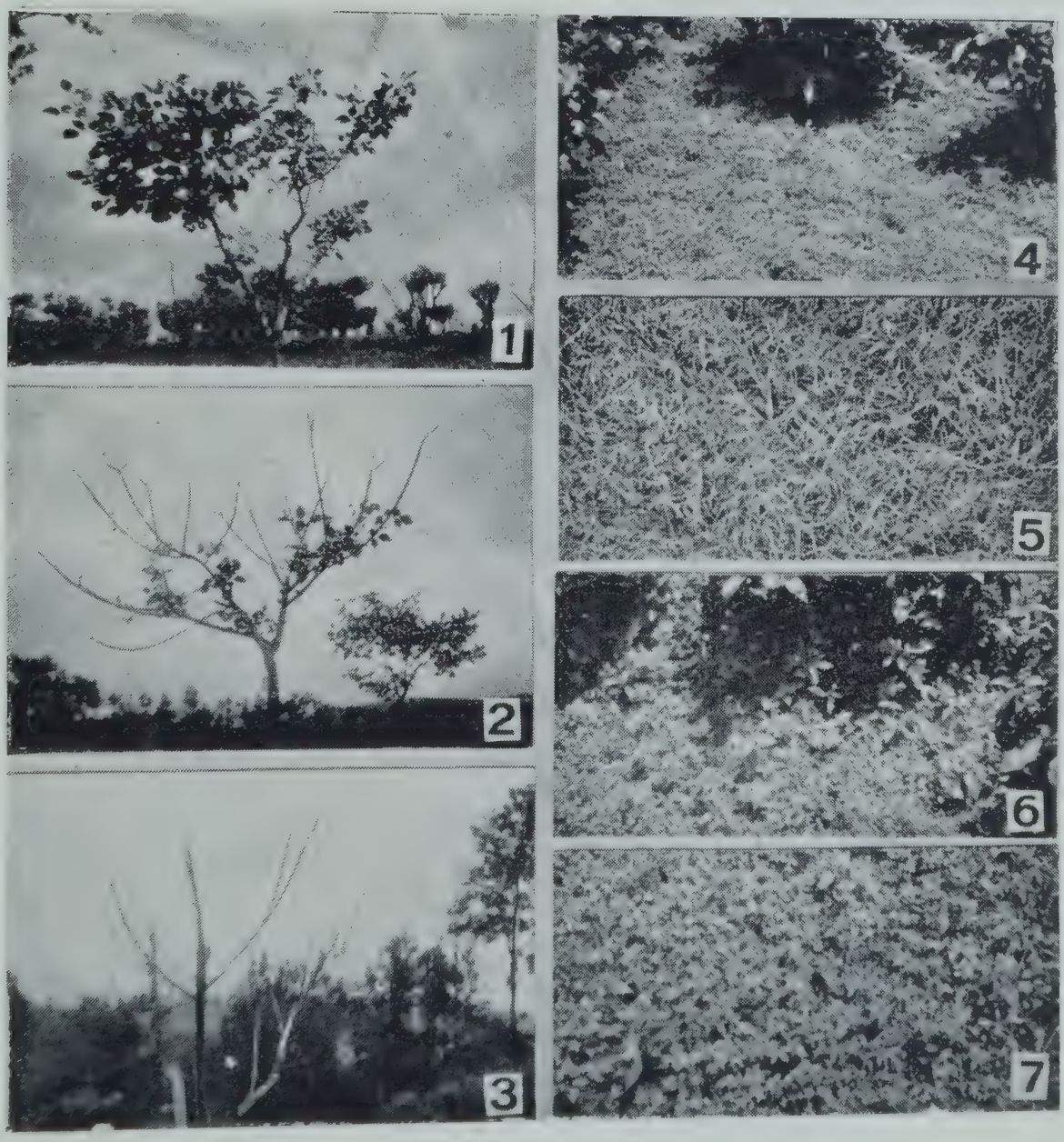

Plate 2

GENESIS OF FERTILIZER RECOMMENDATION IN TEA

V. Ranganathan

Let me now tell you something about the genesis of fertiliser recommendation in tea. Hitherto, we have been recommending the amount of fertilizer to be applied based on the quantity of nutrients removed by the crop – a technique based on the replacement theory. We knew that the method had its own limitation as it disregarded the potential source of nutrients from the soil. However, this method served as a good guide to start with and we were always looking forward for a more rational system than this (3,5). There were certain lacunae in interpreting soil analytical data in relation to crop yields which made our earlier attempts to correlate soil test data with yield a difficult task. With the advancement of knowledge on this subject, we are now in a position to interpret soil test data in relation to yield (1,2,7). Critical analysis of the results of our earlier experiments, particularly the one carried out at Devarshola during the years 1940–1953, has given us indications on the possibility of evaluating fertilizer recommendations based on soil tests. Yet, the practical utilisation of soil test values is not without difficulty.

Two clones growing under identical conditions, side by side, may differ in their yielding capacities (Table 1).

Table 1: Yield levels of clones (5 years from planting).

	B/5/63	B/6/62
No nitrogen	1628 lb/acre	1040 lb/acre
120 lb N/ac	2392 lb/acre	1630 lb/acre
Response per lb of N	6.4 lb/acre	4.9 lb/acre

The quantity of available nutrients in the soil is the same for both the clones but they differ in the capacity to utilize the nutrients that are made available to them. Therefore a crop which has a high capacity to utilize the nutrients takes more nutrients at a given time than the crop with a low capacity. It is, therefore, obvious that nutrients are less wasted from a field with a high yielding crop than from a field with a low yielding crop. Therefore, when we calculate the ratio of nutrient required to yields obtained, it is much less in a high yielding crop compared to the low yielding crop. This was not recognised earlier and hence difficulties were encountered with in correlating crop yields with soil test data and to evolve a suitable basis for making recommendations. With per cent yield concepts, we are able to eliminate the effects due to clones, season and location and are able to show that soil analytical data can be used in tea to make fertilizer recommendation. A given concentration of a nutrient which is continuously replenished in the soil - popularly known as elastic availability - will always support a fixed per cent of the maximum yield that a particular field or clone is capable of yielding under a given set of conditions. For example, say a particular concentration of available nitrogen will support 80 per cent yield, then two clones capable of yielding 3000 and 2000 lb made tea per acre will give 2400 and 1600 lb, respectively. One should realize that by increasing the amount of fertilizers alone one cannot increase the yield indefinitely and there is always a limitation imposed by the capacity of plants to utilize them. I shall now give you some of the salient features of progress which we have made in this direction.

From the long term manurial experiments carried out at Devarshola during 1940-53 (6), we are able to calculate the amount of nitrogen, phosphorus and potassium that can be taken by the crop from the soil source in case no fertilizer is added and also the amount of nutrients utilized from the added sources (Table 2).

Table 2: Nutrient utilization from soil and fertilizer sources

Nutrient	Soil test rating	Soil source lb/acre	Fertilizer source per cent added nutrients
Nitrogen	medium	32 to 87	9 to 43
Phosphorus	medium	8 to 25	0 to 10
Potassium	medium	10 to 53	0 to 80

This has formed the basis of our approach to this problem and we will now see how we have arrived at the recommendations for the various nutrients.

Nitrogen:

The organic matter content in the soil is continuously undergoing mineralization and about 150 lb of nitrogen are released during a year in soil containing about 3 per cent organic matter. This 150 lb can be absorbed by a crop in full or part or lost by leaching. Clones differ in their capacity to utilize the nutrients that are released continuously - the one that readily utilizes, makes use of most of the available nutrients (Table 3).

Table 3: Nitrogen removed in lb/acre from soil containing 3 per cent organic matter

Clone	Nitrogen removed in lb/acre/year	Efficiency of utilization per cent
B/5/63	73	49
B/6/62	47	31

There is no single direct measurement of the capacity of the plants to absorb nutrients as this depends on many factors. However, yield is related to this attribute and can be taken as a criteria of the capacity of plants to absorb nutrients. It may be seen from table 4 how the amount of nitrogen utilized from the soil source depends on the yielding capacity in the different years of the pruning cycle.

Table 4: Yield levels and amount of nitrogen removed from soil source.

(Average for 4 cycles).

Year	Nitrogen removed from soil source lb/acre/year	Range N/lb ac/year	Yield made tea lb/acre
First year	42	32-55	704
Second year	77	65-87	1207
Third year	65	61-72	1013

On an average one per cent of the organic matter in the top 9 inches of soil can contribute about 8 to 22 lb of nitrogen per acre, depending on the ability of plants to utilize the nutrients. This is about 0.5 to 1.5 lb of nitrogen for every ton of organic matter in the soil. Over and above this we have to add nitrogenous fertilizers to maintain higher crop yields. In the last conference we have shown how nitrogenous fertilizers undergo losses when applied to soil and only 13 to 43 per cent of the added nitrogen alone is utilized by the crop, the remaining being lost in a number of ways. The efficiency of added nitrogen is also dependent on how best and how quick nitrogen could be absorbed by the crop. We have used it to calculate the maximum economic dose of nitrogen under different yield levels and availability of nutrients from the soil (Table 5).

Table 5: Organic matter status of the soil and nitrogen requirement.

Organic matter status	Nitrogen in lb/acre for every 100 lb of made tea		
	Low yielding 1000 lb/acre	High yielding 2000 lb/acre	Very high yielding 3000 lb/acre
Less than 2.0% Low	16	12	10
2.0 - 6.0 medium	12	10	8
Above 6.0 high	10	9	7

At present, we have restricted the classification of soils into three but with further experiments we hope to make the recommendation more specific than what we have attempted at present.

Phosphorus:

Tea is able to utilize 8 to 25 lb of P_2O_5 per acre from a field with a medium phosphorus status depending on the ability of the bushes to use this element. This amount of P_2O_5 can support yield upto 1800 lb of made tea per acre, if maximum efficiency is achieved. On an average we may safely take this figure around 1200 lb of made tea per acre. Yields have now gone up and it is common to observe fields yielding around 2000 lb of made tea per acre and it is obvious from the above facts that it will be worth adding phosphatic fertilizers even when the soil contains adequate phosphorus. We have calculated the optimum economic levels of phosphorus for different yield levels and different soil phosphorus levels. We have found that the levels of P_2O_5 required for different yield levels for a given soil phosphorus level differ within a narrow range. Moreover as will be discussed later on, phosphorus is efficiently utilized by tea. Taking all these into consideration we give more or less a blanket recommendation for all yield levels for different soil phosphorus status (Table 6).

Table 6: Recommendations for phosphorus application

Available Soil Phosphorus (P_2O_5) Status*		Phosphorus Requirement P_2O_5 lb/acre
0-10 ppm.	low	50-75
10.1-50 ppm.	medium	25-50
50.1-100 ppm.	high	10-20**
Above 100 ppm.	very high	not necessary

* As estimated by BRAY II modified method

** For yields above 2000 lb made tea per acre

One interesting aspect relating to phosphorus nutrition in tea is that the efficiency of utilization of native phosphorus in soil and added phosphorus through fertilizers is greater than in other crops, like potato, which are also grown in latosols occurring in tea areas. To obtain 50 per cent yield in potato, we have to apply 1134 kg. of phosphorus per hectare as rock phosphate while in tea, 28 kg P per hectare as rock phosphate is sufficient for the same 50 per cent yield. This might be possible if tea has the capacity to absorb phosphorus by mere contact with phosphate particles. If this is true, the placement of phosphatic fertilizers in the root zone will be more effective as phosphorus is practically immobile in the soil. This aspect is being studied in detail in a new experiment now in progress at our Research Station.

This phenomenon also tells us how tea is able to meet its requirment of phosphorus from the soil source without any difficulty. Hence the overall response to added phosphorus is numerically low - it is within 10 per cent of the yields obtainable. By increasing the number of replications in a field experiment of this nature it is possible to obtain more precise information, but the number of replications required to signify this small response is very high and it may not, therefore, be worthwhile to carry out field experiments with innumerable number of replications. We have now utilized the per cent yield concepts to identify response and calculate the efficiency coefficients of native and added phosphorous. With this we have calculated the economic doses at different yield levels and different soil phosphorus contents discussed earlier.

Potassium:

Potassium removal in tea is about 35 to 100 lb. of K_2O per acre per annum and it is low when compared to 300 lb. K_2O per acre for sugarcane and 110 lb. for high yielding paddy. In spite of this, the response to potassium is much pronounced in tea than in other crops. On further investigation into the problem, we found that the degree of potassium saturation in high yielding tea fields is about 7 per cent while in a good sugarcane or paddy field it is around 5 per cent. This means, tea requires a high concentration of potassium in the soil solution. This is usually the case with plants utilizing potassium from the soil solution. We have also shown in the previous paper how difficult it is to build up the potassium status of the South Indian tea soils and how frequent applications and placement of potassium help in maintaining the concentration at the desired level for efficient utilization of this nutrient by tea.

Nitrogen-potassium interactions in tea play a key role in maintaining crop yields. This was clearly brought out by us as early as in 1953 (4). We have now calculated the optimum nitrogen-potassium ratios to be used under different yield and soil nitrogen and potassium levels (Table 7).

Table 7: Recommendation for potassium application

Soil Nitrogen status	Yield Potential	N: K* Ratio Low Soil Potassium	Medium Soil Potassium
Low and medium	Low yielding (less than 1500 lb. made tea/acre)	2:1	2:1
	High yielding (above 1500 lb. made tea/acre)	2:1	5:2
High	Low yielding	10:7	2:1
	High yielding	5:3	2:1

* K as K_2O

Wherever there is depletion of soil potassium arising from exceptionally high yields and/or abnormally high rainfall, nitrogen: potassium ratio has to be fixed as for low soil potassium fields, irrespective of the yielding capacity of the fields. Similarly when potassium utilization by plants is made difficult by high cation exchange capacity and/or high organic matter content, the fields should be treated as low in soil potassium for fixing the nitrogen-potassium ratio, irrespective of the potash status of the soil.

We are now able to put forth a basis for fertilizer recommendation based on our earlier experiments on mature tea. The experiments which we have now laid out in young tea also support the results we have obtained earlier, thus confirming that we are on the right lines. Our experiments are continuing and as more data accumulate we may be in a position to reclassify our tea soils as far as their available nutrient status is concerned and make a more precise recommendation on fertilizer application to tea.

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MITES, A MAJOR ECONOMIC PROBLEM - RECENT TRENDS IN THEIR CONTROL

G. N. Rao

The object of this paper is to highlight the achievements of the department in the control of mites and their impact on the industry in S. India.

Although mites were recorded on tea well over half a century ago, they began to gain importance as a major economic problem only in the last two decades or so. There appears to be some coincidence between the use of copper fungicides for blister blight control and the successful control of *Helopeltis* with DDT on one side and the sudden flare up of mites on the other. Several theories have been put forward in this connection viz., (1) the sudden removal of shade, (2) excessive use of nitrogenous fertilizers, (3) positive influence (Table 1) of copper fungicides on the build-up of purple mites (Venkata Ram, 1963; Rao, 1967).

Table 1

Effect of copper fungicide on build-up of purple mites

Treatment	Purple mites per unit area			
	1965—66		1966—67	
	Trials			
	I	II	I	II
Copper fungicide 6 oz/acre	285	264	382	364
Nickel chloride 3 oz/acre	87	40	259	207
Control	153	120	301	242

Mites are now more or less widely distributed throughout S. India and are active during the dry weather, when their presence is really felt by the planters.

Severe infestation of mites not only results in a characteristic sickly appearance of affected fields but also leads to acute debilitation of bushes, defoliation in extreme cases and a direct loss of crop as well. A loss amounting to 25% of the total crop was not uncommon in N. E India due to the ravages of red spider alone (Das, 1963). It was estimated that the annual loss of crop due to mite damage could well be in the order of 150-300 lbs. made tea per acre in the High Range (Raghavan Nair, 1957). Crop losses due to purple mite alone were reported to be in the region of 50 to 150 lbs. made tea per acre in the Nilgiris (Ananda Rau, 1960). This Department has proved (Rao and Subramanian, 1968) that pink and purple mites cause considerable crop losses and that timely control measures pay off good dividends.

In the early days sulphur was the only available acaricide. And even to-day it is still the cheapest and most effective miticide, though under S. Indian conditions sulphur cannot be used on bearing tea due to its tainting properties. Experiments have shown that upto 4 to 6 weeks' interval would be necessary between spraying and manufacture of tea in order to completely avoid sulphur taint.

The next stage was when chemicals like Aramite were tested and used against tea mites. Although Aramite proved to be extremely effective, it was soon realised that it had carcinogenic properties and was, therefore, withdrawn.

In the last decade we screened several chemicals with acaricidal properties, systemic formulations and granular compounds with a view to assess their value as miticides. Studies have also been in progress for evolving the number of spraying rounds needed for economic control, the optimum volume of spray fluid (gallonage) required per acre, concentration of chemical in the spray fluid and the optimum acreage that could be covered per machine.

Based on the above studies, it was found necessary to put out a spray volume of 25 to 30 gallons/acre with a motorised mist blower and a minimum of 60 gallons/acre with pressure retaining knapsack sprayers to obtain effective control of mites depending on the age of the field. Any drastic reduction in the volume of spray fluid per acre with a view to get more task per day would only result in inadequate coverage leading to unsatisfactory control of the pest and a waste of chemical and labour. We know of instances where estates have tried to control mites with a mist blower putting out only 4 to 10 gallons/acre and getting a task of 8 to 15 acres per man day !

Great care and thought are needed in recommending pest control measures in tea as one has to take into account the problems of taint, toxic residues and hazards to operators. We are alive to this problem and our recommendations are so oriented as to give due consideration to this aspect. Consequently only chemicals which have been cleared by the US FDA are recommended for use on tea in bearing. In the last few years, three chemicals have been cleared by the US FDA for use on tea. They are Kelthane (45 ppm), Tedion (8 ppm) and Ethion (10 ppm) and a few more chemicals are awaiting clearance.

An unrestricted choice of effective and safe chemicals should be there in order to overcome the problem of resistance. From this point of view, the department has not lagged behind and we are screening several chemicals every year. However, it is also necessary that more and more chemicals should get the FDA clearance as otherwise the choice of chemicals for use on tea in bearing would become very limited.

Until recently, estates were depending solely on hand operated sprayers for plant protection work, getting a very poor outturn per machine in terms of area, having to put out large quantities of spray fluid. As finding water and its transport to the work spot during dry weather was yet another problem, there has been a partial switch over to the use of motorised mist blowers, which cover a comparatively larger area with a lesser spray volume and are hence more economical.

In the past, most of the acaricides were generally used at 1 pound of the formulation/acre in 100 gallons of water (0 1% strength or 1:1000 dilution) which is commonly known as 'the knapsack dilution rate' in planting circles and 60-100 gallons of this fluid was being put out per acre with hand operated machines. We felt that there was some loss of chemical due to run off in the case of high volume spraying with conventional sprayers. Our studies in the last few years have clearly shown that it is possible to effect some reduction in the quantity of chemical per acre, using knapsack dilution rates with mist blowers (Ananthakrishnan and Krishnamurthy, 1964; Rao, 1965) and putting out only 20, 25 or 30 gallons per acre depending on the nature of the pest and age of the field from pruning (Tables 2,3,4).

Table 2

Efficacy of Akar and Kelthane against purple mite: at 16 oz/acre and 1:1000 sprayed with mist blower at 20 gal/acre

Treatment	% control obtained after 1st application				45 days after 2nd application
	hrs.		days		
	48	96	10	15	
A	100	100	94	98	55
B	99	100	93	99	51
C	100	100	99	100	86
D	100	100	98	100	84

A = Akar 16 oz/ac; C = Kelthane 16 oz/ac

B = „ 1:1000 ; D = „ 1:1000

In this experiment against purple mite, Akar and Kelthane were sprayed with a mist blower @ 20 gallons/acre. In one case the two chemicals were used at 1:1000 dilution and in the other 1 pound of the formulation was put out per acre in 20 gallons water. It would be seen that the percentage control of purple mites obtained was more or less similar, suggesting that knapsack dilutions used in mist blowers would give equally good control, leading to a certain amount of saving in the chemical used.

Table 3

Efficiency of systemic compounds sprayed with knapsack sprayer and mist blower: % reduction of red spider after spraying.

Treatment (dilution of Phosphamidon)	Vol. gal ac.	Machine	Week(s) after 1st spray		Week(s) after 2nd spray	
			1	3	1	3
A 1:5000	60	K	100	99	100	100
B 1:5000	20	M	98	97	100	98
C 1:1000	20	M	99	92	100	98

K = knapsack sprayer

M = motorised mist blower

Results similar to the above were obtained with a systemic insecticide/acaricide (Phosphamidon-Dimecron 100) against red spider (Rao, 1966). Here the comparison was made between (a) Dimecron 100 at 1:5000 dilution sprayed with a knapsack sprayer @ 60 gallons per acre - corresponding to 1:1000 dilution or knapsack dilution;

(b) Dimecron 100 at the same dilution (1:5000) but sprayed with a mist blower at 20 gallons/acre; and (c) Dimecron 100 at 1:1000 dilution sprayed with a mist blower at 20 gallons/acre. The results (Table 3) clearly show that the three forms of spraying were equally effective. These earlier findings were further confirmed in a recent experiment against pink mite with different doses of Kelthane per acre. The spray volume was kept constant at 20 gallons/acre and this was put out with a motorised mist blower; 3.2, 6.4, 9.6, 12.8 and 16.0 oz. of Kelthane per acre were used, the first corresponding to 1:1000 dilution and the last the standard dose of 16 ounces/acre. Two treatments were imposed at an interval of 3 weeks, the first on 15th Nov. and the second on 7th December. All the treatments gave economic control upto 4 weeks after the second treatment (Table 4), suggesting that a certain amount of chemical could be saved.

Table 4

Control of pink mites with different doses of Kelthane sprayed with mist-blower at 20 gallons per acre.

Kelthane oz/ac	No. of live pink mites weeks after 1st spray			2nd spray			
	1	2	3	1	2	3	4
0 (con)	taken as 100 at each observation						
3.2	1	0	14	2	6	9	9
6.4	0	0	0	0	2	1	7
9.6	0	0	0	0	4	0	5
12.8	0	0	0	0	0	0	5
16.0	0	0	0	0	0	0	3

The trend of build up of pink mite population is depicted in Table 5. Accordingly it is felt that the pest should be tackled early in the season (Nov / Dec) with two rounds of spraying, followed by another two rounds later.

Table 5

Pink mite population trends during 69/70

Nov. '69			Dec. '69		
8	15	25	8	15	29
1900	1050	650	200	300	600
Jan. '70			**Feb. '70**		
5	12	28	2	9	24
1150	1000	850	1000	1550	2200
March 1970					
2		10		16	
1350		1950		850	

It has to be pointed out that the success of any plant protection measure depends mainly on proper coverage. In order to achieve this, not only the correct volume of spray fluid should be put out, but the spraying technique itself should be faultless. In the case of mites, the inside of the bushes have to be sprayed thoroughly to see that the lowerside of the leaves are properly drenched, whereas in the case of blister control only the plucking surface needs to be covered. Thus there is an ocean of difference between blister control and mite control.

As cost of production is going up, naturally estates look for areas where saving could be made. Unfortunately the axe falls on the estimates for pest control, but with what result? Pests are not controlled and yields are affected. Is this not false economy?

Some economy is certainly possible (1) by using knapsack dilution rates with mist blowers and (2) by spraying combined insecticide/acaricide in one operation when both mites and thrips occur at the same time. In the last few years we have tested several such broad spectrum chemicals and they have shown varying degrees of promise, e.g., Ethion. Trithion, Delnav, Kilval, Zolone, Anthio. Thiodan, Dimethoate, Sumithion, and Azodrin. The latter has shown considerable promise as an outstanding insecticide/acaricide. However, only Ethion has so far been cleared for use on tea in bearing.

Among the recently tested acaricides, Acrex (Dinobuton) Galecron (Chlorophenamidine) and Plictran (Triphenyltin hydroxide) proved to be extremely good against mites. While working with Plictran (organotin compound) we found that this compound has antifeeding properties. This aspect is gaining importance in other parts of the world. The study and utilization of this property in agrochemicals is bound to have far reaching effects on the very concept of pest control by chemicals.

A number of compounds with systemic action are now available in granular form, to be applied to the soil. The active chemical in the granules gets released with the aid of soil moisture and is taken up by the roots and translocated to the various parts of the plant. In the last couple of years we have tested a few such compounds (Table 6) in the nursery and in new clearings and found them to be extremely useful in keeping mite populations at economic levels (Table 7) and also preventing root-knot eelworm for upto 3 months at rates as low as 1 g/nursery seedling and 10 g/plant in new clearings (Rao, 1969).

Table 6

Systemic granular compounds tested

Name	Supplier	rate per plant (gms)	
		Nursery	New clearings
Nemafos 10%	Cyanamid	1, 2, 3	10
Solvirex 5%	Sandoz	,,	,,
Temik 10%	U. Carbide	,,	,,
Terracur 10%	Bayer	,,	,,
Thimet 10%	Cyanamid	,,	,,

Table 7

Efficacy of Granular Systemic Compounds in mite control

Treatment	% Control of mites—days after treatment							
	15		30		45		75	
	PK	PR	PK	PR	PK	PR	PK	PR
Nemafos	84	96	81	92	83	62	87	88
Solvirex	88	97	89	97	90	80	87	88
Temik	99	99	100	100	99	97	99	100
Terracur	85	87	82	95	84	92	80	87
Thimet	80	81	84	100	69	88	63	92

PK = Pink mite
PR = Purple mite

If we have to maintain our superior position as a major tea exporter, we have necessarily to increase our production per unit area and at the same time improve the quality of our teas. No doubt, the average yield in S. India has gone up in the last two decades from 650 lb/acre to about 1100 lb/acre. This phenomenal increase in yield is to a very large extent due to the keen interest evinced by our planters in scientific methods and the timely plant protection measures taken by them. These efforts have to be further strengthened, to meet the ever increasing competition in the world markets.

Earlier we gave an indication of the economic losses caused by mites and we now wish to bring home the fact that timely control measures pay off big dividends. In this experiment four different chemicals, viz. Akar, Ethion, Kelthane and Morocide @ 1: 1000 dilution sprayed thrice with a mist blower at a volume of 30 gallons/acre were compared with untreated control; all treatments have controlled the pest effectively (table 8) and have given higher yields than the untreated ones.

Table 8

Comparative efficacy of four acaricides

Treatment	% control of mites a week after					
	1s spray		2nd spray		3rd spray	
	PK	PR	PK	PR	PK	PR
Akar	84	88	90	93	90	96
Ethion	83	83	75	67	91	88
Kelthane	89	96	89	87	95	97
Morocide	84	88	81	87	89	89

PK = Pink mite
PR = Purple mite

The monetary benefits accruing as a result of timely spraying are presented in table 9.

Table 9

Benefits of timely spraying for mites

	Akar	Ethion	Kelthane	Morocide	Control
Green leaf in 18 rounds (lbs)	949	977	1027	963	875
Increase in green leaf (lbs)	74	102	152	88	—
Calculated increase in green leaf/acre (lbs)	371	508	762	444	—
Calculated extra made tea/acre (lbs)	85	117	175	102	—
Approximate gain/acre @ Rs. 5/kg	193	266	398	232	—

It may be noted that Rs. 200/- to Rs. 400/- could be gained per acre in a single season, by controlling mites effectively, by investing only a small fraction of these gains (Rao and Subramanian, 1968).

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MILESTONES IN BLISTER BLIGHT CONTROL

C. S. Venkata Ram

Blister blight of tea (Fig. 1) incited by the fungus *Exobasidium vexans* Massee was first recorded in southern India in August 1946. Since then numerous reports on the epidemiology, and control of the disease have been published, including a critical review of the blister blight situation in 1961 (Venkata Ram, 1961d). In the present article the work of this Department on chemical control of the disease over the past quarter century is summarised, high-lighting the milestones of progress.

Losses: Annihilating losses to the tea industry in southern India were caused in the early years of blister blight (Subba Rao, 1946) and according to the author (Venkata Ram, 1964c) 36 million pounds of tea were lost annually between 1948 and 1952 when large scale crop protection measures were yet to be implemented. Comparisons between the crop harvested from tea fields protected by fungicide spray and those left unsprayed indicated a loss of 50% in a six month period (de Jong, 1952, 1953), which is not unrealistic as seen from the results of a recent *ad hoc* experiment (Table I). Three rates of fungicide application were compared; in one a combination of 3 oz each of nickel chloride and a 50% copper oxychloride was employed, in the other two 3 and 1 oz. of copper oxychloride alone were used. With the combination spray a crop increase of 136% was recorded in the month of August when blister blight was severe (Venkata Ram, 1968, 1969b), whereas in the case of lower doses of straight copper fungicides the increase was 78% and 57%. Undoubtedly the crop increase from fungicide application appears less striking when it is averaged over a 4 to 6 month period than when attention is focussed on a short period of severe blight infection. In Table I data are presented of crop increase, or decrease, recorded in the three fungicide treatments over the unsprayed control. Between August 14 and September 14 the increase in each harvest was 200, 300, 110 and 109 per cent at the highest fungicide dosage, in contrast to the appreciably lower increase in the other two treatments. These results laid emphasis on the losses which result from fungicide usage at sub-optimal dosage, contradicting the report of the Tea Research Institute of Ceylon that crop losses occurred only at usage rates below 0.5 oz. copper fungicide per acre and that between 0.5 and 8.0 oz application rates the difference was insignificant. It was also recorded (Venkata Ram, 1961b) that a saving of 9 fungicide spray applications in 18 weeks led to crop loss of 46 lb made tea per acre in the same period, hence extending the interval between spraying could become uneconomical beyond a certain point. The severity of blister blight infection on tea when the plants are either not or inadequately protected is shown in Fig. 1.

Table 1. Percentage increase or decrease in tea crops in comparison to untreated resulting from different fungicide usage.

	Treatment	20/7	4/8	14/8	25/8	4/9	14/9	23/9	3/10
1.	3 oz. copper fungicide + 3 oz nickel chloride/acre	+33	+60	+200	+300	+110	+109	+33	+4
2.	3 oz. copper fungicide/acre	+20	+53	+90	+154	+80	+70	+17	−4
3.	1 oz. copper fungicide/acre	0	+53	+66	+82	+5	+20	+5	0

Early Control: Within a year from the occurrence of blister blight, control measures which resulted in 50% increase of crop were published (Anonymous 1949) but the use of 100 gallons of spray fluid per acre in these trials (Anonymous, 1948, 1949) was impracticable on extensive field scale when spraying had to be repeated at frequent intervals. The introduction of knapsack sprayers fitted with low volume nozzle in 1949 and the fixing of the tolerance limit for copper residues in tea at 150 ppm., through the efforts of the Tea Research Institute of Ceylon, gave not only an acceptance of the possibility of field scale spraying with copper fungicide but also a powerful impetus to further experimentation with new and improved organic and inorganic formulations. The early work on the control of blister blight has been previously reviewed (Venkata Ram, 1961d, 1964c).

Inorganic fungicides: Bordeaux mixture, cuprous oxide, copper oxychloride formulations and fungicides based on mercury were early tested at different rates using 15 gallons of the spray fluid per acre with satisfactory results. Because of phytotoxicity the mercurials had to be discarded while both from the point of taint and ineffective control fungicides based on sulphur could not be seriously considered. Until 1960, then, only copper fungicide was in use in the control of blister blight. One of the interesting observations made in connection with the wettable copper fungicide (Fig. 2) was that formulations of colloidal copper applied at a rate to give 1.25 oz copper, as metallic, per acre was as effective as 50% wettable powder used at 3 oz copper as metallic (Jayaraman and Venkataramani, 1957; Jayaraman and Venkata Ram, 1959); obviously the particle size of copper influenced the fungitoxicity of the formulation. From the point of view of economy in copper application and lesser copper residue in tea the colloidal formulations have a distinct edge over the 50% wettable powder, but unfortunately they offer no reduction on cost.

A major break-through in the chemical control of blister blight was made in 1960 when both in laboratory experiments and field trials (Table 2) it was observed that nickel chloride hexahydrate gave dramatic control of the disease (Venkata Ram, 1961a; Venkata Ram and Jayaraman, 1961) and that nickel at concentration equivalent to one-fourth that of copper used, as metallic, was superior to copper (Fig. 3). When copper and nickel fungicide sprays were put out in blocks where the initial level of blister infection was 84%, the disease level was reduced to 24% and 13% after 3 and 5 weekly applications, respectively, of nickel chloride but no such striking disease control was achieved with copper (Fig. 3).

Table 2. Control of blister blight with nickel chloride and copper fungicide spray application at weekly intervals.

Treatment	Rate used per acre	Percentage shoots infected on						
		July			August			
		7	22	29	5	12	19	26
50% Cuprous oxide	6 oz.	9.0	14.0	14.5	34.0	27.2	28.2	14.0
Nickel chloride hexahydrate	6 oz.	12.5	10.2	8.0	25.0	25.0	15.5	4.0
Control		70.2	55.0	72.0	90.0	85.0	87.0	69.0

Eradicant fungicide treatment: Results obtained in the early trials with nickel chloride pointed to eradicative control properties of nickel; this was confirmed subsequently by extensive laboratory tests (Venkata Ram, 1963a). Dilute sprays of nickel chloride hexahydrate applied on newly formed blister prevented sporulation of the blisters and at 0.2% concentration 100% inhibition of sporulation was recorded (Fig. 4a). At the same concentration the spray applied to leaves artificially infected with *Exobasidium vexans*, the causal fungus, at intervals of 24, 48, 72 and 96 hours from inoculation prevented lesion formation (Table 3). Amendment of soil with nickel ammonium sulphate 8 days prior to inoculation of young, susceptible clonal plants with *Exobasidium* spores gave systemic control (Venkata Ram, 1964a) but the treatment was phytotoxic. Several salts of nickel were compared for their efficacy against the blister blight disease, but the chloride was more active than the acetate, borate, nitrate and sulphate (Venkata Ram, 1962a). The efficacy of nickel chloride spray, however, is appreciably influenced by the nature of the wetting agent used with it and non-ionic wetting agents have been found superior to anionic wetting agents (Venkata Ram, 1963d, 1969b). Leaf impressions on filter paper steeped in a 0.5% solution of rubeanic acid in alcohol were studied for the pattern of deposit of nickel chloride spray, with and without wetting agent, when striking differences were observed. Without wetting agent the spray is retained on the surface of the tea leaf as discrete droplets, whereas with wetting agent the whole surface is uniformly covered (Fig. 4b). Good coverage is an important prerequisite to the efficacy of eradicant sprays. It was further shown that following exposure of sprayed leaf to even short duration rainfall of low intensity, tests for surface nickel were negative, the loss from wash off being advantageous in keeping the level of this metal low in made tea, generally around 35 ppm. as opposed to 15 ppm in the unsprayed leaf (Venkata Ram, 1963f).

Table 3. Effect of 0.2% nickel chloride treatment of artificially inoculated tea leaf on blister development.

Treatment after (hours)	Number leaves inoculated	Number leaves with blister	Number of blisters seen 14 days after inoculation
0	24	0	0
24	24	0	0
48	26	0	0
72	26	0	0
96	24	1*	1*
Control	26	26	72

* non-sporulating lesion seen before chemical treatment.

The eradicant nickel provides a potential advantage to the tea industry in combating the blister blight disease because with protectant copper fungicides timing is very important, especially when spraying is started initially in the blister blight season, or resumed after interruption late in the season after a break in bright, sunny weather. When spraying protective fungicides the margin for error in timing is small, whereas with an eradicant fungicide application is effective even after infection has occurred (Fig. 3). Dusting with nickel, though effective in

controlling blister blight (Venkata Ram, 1963e), presents considerable practical difficulties owing to the hygroscopicity of nickel salts. Apart from the advantage in obtaining the eradication of latent blister lesions *in situ*, it was further found that with nickel chloride spray application the build-up of mite pests was not stimulated vis-a-vis copper spraying (Venkata Ram, 1963c, 1966b, 1967a, 1968, 1969c; Rao, 1967); typical results are included in Table 4. On the basis of these findings recommendations were made on timing nickel chloride sprays to keep the incidence of mite pests at a low level (Venkata Ram, 1967b).

Table 4. Influence of copper and nickel application on pink and purple mites.

Treatment, dosage/acre	Average number of mites on 20 leaves in 3 replicate plots					
	Pink mite on Feb. 6			Purple mite on May 5		
50% Copper oxychloride 6 oz.	236*	332*	229*	2516*	1732*	1796*
Nickel chloride, 4 oz.	96	92	32	700	372	608
Control, unsprayed	40	52	66	180	460	548

* significant at 1% level.

Due to the world shortage of nickel, the threat of scorch attending on the indiscriminate use of nickel chloride and as an important advance on the reduction of the fungicide, as metallic, recommendations were made in 1966 on the combined use of nickel chloride and 50% copper oxychloride. A mixture of 2 oz. each per acre gave significantly greater disease control than 4 oz. of the copper fungicide used alone and comparable protection to that of 4 oz. nickel chloride (Venkata Ram, 1966a, 1967a) the level of metallic element applied in the straight copper, combined and straight nickel treatments, being 2 oz. 1.5 oz and 1 oz , respectively. An experiment to determine the optimum ratio of copper to nickel in the combination spray (Venkata Ram, 1966a), from the twin aspect of disease control and economy, pointed to two combinations which gave higher levels of protection than the others tried, namely, either 2 oz copper and 0.25 oz. nickel, or 1 oz. copper and 0.5 oz. nickel, as metallic per acre (Table 5); the latter is the same as 2 oz. each of 50% wettable copper and nickel chloride and it is commonly in use.

Table 5. Efficacy of nickel chloride and copper oxychloride combination treatments against blister blight.

Rate of copper and/or nickel (oz./acre, metallic)		Percentage shoot infection on					
		July			August		
		16	23	30	6	20	27
Cu.	Ni.						
2.0	0.25	7.5	3.5	4.7	11.5	9 0	6.5
2.0	0.125	5.0	5.5	10.5	13.0	12.0	9.0
1.5	0.125	10.0	5.5	14.0	18.5	11.5	8.0
1.0	0.50	8.0	6.0	8.5	12 5	4.5	7.0
1.0	0.25	12.5	9.5	7.7	13.0	19.5	8.0
1.0	0.125	8.0	11.0	20.5	17.5	13.5	11.0
—	1.50	3.5	3.0	7.0	10.5	4.0	5.5
C. D. at 0.05 = 7.3							

Organic fungicides: With only a few exceptions (de Jong, 1954; Jayaraman and Venkataramani, 1957), organic fungicides failed to give the same range of disease control that is possible with copper fungicides and nickel chloride (Venkata Ram and Jayaraman, 1960, 1961; Venkata Ram, 1964b). Typical results are presented in Fig. 5, of blister blight control achieved with organic formulations at economic usage rate and it is readily seen that the control in all cases is well below the level of protection achieved with nickel chloride and copper fungicide, though at higher dosage the organic formulations gave adequate protection. Recently, two organic fungicides, namely, Daconil - 2787 (Venkata Ram, 1966a, 1967a, 1968) and Difolatan, gave satisfactory blister control when applied at levels between 8 and 16 oz. per acre, but Difolatan was found to impart an unacceptable taint to the tea. Organic compounds with organic radicals and organo-tin compounds were also tested extensively but none gave satisfactory disease control (Venkata Ram, 1964b, 1965). Antibiotics and mixtures of antibiotics with copper (Venkata Ram and Jayaraman, 1960; Venkata Ram, 1967a), also failed to indicate any potentiality in the control of blister blight in view of either high cost or poor performance.

Tenacity of fungicides: The tenacity values of various commercially available copper fungicides were shown to vary considerably in laboratory tests, but the values did not bear a direct relationship to the blister blight control achieved with the formulation in the field (de Jong, 1956). Undoubtedly, the tenacity value of a fungicide depends on the test method. Values given in respect of copper fungicides by de Jong (1959) are high in comparison to those obtained by Jayaraman (1960) and in a recent investigation when copper deposits on tea leaf were held under a rainfall simulator. The force of impact of the water droplets on the leaf apparently caused considerable wash off and under simulated rainfall of heavy intensity the dry deposit of a 50% copper oxychloride was almost totally lost in a short period of 2 minutes (Table 6 and Fig. 4c). Under simulated rainfall of low intensity the fixed copper residue is retained on the leaf upto approximately 40% even on prolonged exposure (Fig. 6). As opposed to fixed coppers, the deposits of Bordeaux mixture were more resistant to wash off by simulated rainfall (Fig. 6). Tenacity of a fungicide is important only to a point, because of the frequent sprays that have to be applied of necessity. When an experiment was performed using special stickers with organic fungicide and technical copper oxychloride, the sprays did not give control of blister blight which was superior to that achieved with formulated 50% fixed copper (Venkata Ram and Jayaraman, 1961). The practical application of the knowledge gained from the experiments on the tenacity of fungicide in the control of blister blight is that application of fungicide spray followed by rain even after a short interval of 2 to 3 minutes will result in significant disease control, as earlier observed (Venkata Ram, 1959).

Table 6. Rainfastness of dry and wet deposits of two formulations of 50% wettable copper oxychloride on tea leaves.

Treatment	Formulation	Microgram copper per leaf	
		dry	wet
14 mm. rain in	Blitox 50	6.75	0.89
2 minutes	Fytolan	5.25	0.62
42 mm. rain in	Blitox 50	4.89	0.62
2 minutes	Fytolan	3.75	0.50
Control, not	Blitox 50	131	163
exposed to rain	Fytolan	115	126

Spraying on extended rounds: Fungicides that gave excellent control of *Exobasidium* on spraying rounds of 7 or 10 days generally failed to give satisfactory control when the interval between spray applications was increased to 14 days. Earlier experiments with 50% wettable cuprous oxide showed that crop losses occurred when the spraying interval was 14 days, compared to 7-day and 10-day rounds (Venkata Ram, 1961b). The results fit in with the more recent observation where a distinct correlation between the level of infection and crop loss was noticed (Venkata Ram, 1968). The success of timing spray application based on weather conditions is a line of enquiry which has produced interesting reports. Scientists in Indonesia and Ceylon devised several spray warning systems whereby fungicide application is timed on the basis of sunshine records, but in the experiments carried out in southern India these spray timing schedules proved unsatisfactory (Venkata Ram, 1962c). The failure to achieve satisfactory protection beyond a certain limit of time is obviously due to the fact that the freshly exposed areas on the vigorously growing tea leaf are not covered by the fungicide; at the end of 7 and 14 days the newly exposed area on the leaf increases by 13 and 87 times, respectively.

Systemic fungicides: Whilst testing of systemic fungicides against blister blight was initiated only 4 years back, two derivatives of 1, 4-oxathiin have been found to give excellent systemic control of the disease when tea seeds were treated with these compounds and when they were applied to soil around tea seedlings or potted clonal plants (Venkata Ram, 1968, 1969a, 1970). Fig. 7 shows diagramatically the failure to induce blisters by artificial inoculation of young shoots of a susceptible clonal plant when the systemic fungicide was painted on the lower, mature leaf 5 days prior to inoculation; the untreated control developed blisters. In Table 7 results are presented of natural blister incidence on tea seedlings raised in beds which received treatment with 1, 4-oxathiin derivatives and it is seen that the systemic compounds greatly reduced the incidence of blister attack. The practicability of treating mature tea with systemic fungicides on a field scale, and the economics thereof are subjects still under investigations, but in the nursery the potentiality of using such fungicides is obvious.

Table 7. Incidence of blister blight on seedlings raised in beds, untreated and treated with 1, 4-oxathiin derivatives.

Treatment	g/100 sq. ft.	Percentage			
		Unattacked	Mild leaf infection	Severe infection	Stalk infection
D 735	10	44	44	12	0
	20	42	38	20	0
	40	52	33	15	0
F 461	10	60	35	5	0
	20	52	44	4	0
	40	80	15	5	0
Control		1	18	1	80

Spraying equipment: Theoretically the control obtained from the application of the same level of fungicide per acre, with the same spraying equipment, should not vary within a narrow range of difference in the volume of the spray fluid, but in an *ad hoc* experiment it was observed that 56.14 litres of the spray fluid, per hectare, gave significantly better protection against blister blight than did 36.66 and 22.48 litres (Venkata Ram, 1963b), although the fungicide dosage per hectare was the same in all cases. In another experiment the control achieved with 3 oz. nickel chloride in either 3 or 6 gallons of water per acre, applied with air blast sprayers, was significantly better than with 2 gallons (Venkata Ram, 1965). This was shown to be due to larger fungicide deposits on the tea foliage with higher volume of carrier (water) used (Venkata Ram, 1969b). Perhaps the relatively poor disease control obtained from mist blowing the fungicide spray with micron sprayers (Venkata Ram, 1968, 1969b is due to the low volume used with this type of spraying equipment. The droplet spectrum produced by a particular spraying machine would determine largely the efficacy of fungicide deposition since aqueous sprays have a fairly high rate of evaporation and the droplets size of such sprays will decrease rapidly under certain weather conditions. A droplet of water initially 100 microns in diameter (0.1mm.) will evaporate completely in 16 seconds when falling at a terminal velocity of 27 cm. per second at 20°C. temperature and 60% relative humidity. The droplet size obtained when copper fungicide spray was blown with micron and air blast sprayers is given in Table 8 and photographs of such droplets of a fluorescent dye taken under ultraviolet illumination are included in Fig. 4d, e and f. Such critical studies have thrown much light on the results obtained in the field with regard to the poor performance of micron sprayers, and provided an explanation for the efficacy of control dropping sharply 2 rows away from the spraying lane (Venkata Ram, 1969b), leading to the recommendations of practical guide lines in spray application for the control of blister blight (Venkata Ram, 1963f). Spraying of tea with the micron and air blast sprayers is illustrated in Fig. 8.

Table 8. Spray droplet size blown by micron and air blast sprayers.

Droplet size in microns	Micron sprayer	Air blast sprayer	
		34 l/hr.	60 l/hr.
45	14%	—	—
60	17	—	—
75	32	2%	—
90	7	10	—
105	14	9	10%
120	10	15	8
150	6	30	20
180	—	23	21
225	—	6	25
250	—	6	11
300	—	—	5

Because improvements in fungicide formulations and spraying equipment occur continually, screening of fungicides and testing of plant protection equipment have to inevitably receive high priority in the research programme of this Department. In 1970, i.e., the current year, a test chemical gave dramatic control of blister blight, superior to that achieved with any other fungicide hitherto investigated at economic usage rates. Much work is still to be done before the practical utilization of these findings can be evaluated. This could very well be the next milestone in this department's contribution to the tea industry for yet better disease control, just as the introduction of nickel chloride marked a major milestone of progress a decade back.

Explanation of Figures

Fig. 1. Shows severe blister infection on a single leaf and on tea bushes in the field.

Fig. 2. Shows the relative efficacy of fixed copper formulations in the control of blister blight; solid horizontal columns indicate metallic copper content of the formulation.

Fig. 3. Shows control of blister blight with nickel chloride spray (solid line) applied in tea with a high pre-existing disease level; broken lines indicate treatment with copper fungicide and arrows point to the time when treatment commenced.

Fig. 4. Shows (A) inihibition of sporulation of an individual blister (top) by dilute sprays of nickel chloride, in comparison to untreated lesion (bottom); (B) The effect of incorporating wetting agent with nickel chloride spray (right) on coverage (the leaf on the left received the spray without any wetting agent); (C) Copper deposits on leaf exposed to 14 mm. rainfall in 40 minutes (left) and in 2 minutes (right); (D) Fine deposit of spray photographed under ultraviolet light; (E, F) Relatively large droplets deposited owing to coarse atomization.

Fig. 5. Shows blister control achieved with various organic fungicides; figures within the filled columns indicate the dosage in ounces per acre.

Fig. 6. Shows the retention of copper fungicide on tea leaf exposed to low rainfall intensity.

Fig. 7. Shows systemic control of blister blight with a derivative of 1, 4-oxathiin (F-461). The untreated plant on the right developed numerous blisters.

Fig. 8. Shows spray application with an air blast sprayer (top left), Micronette (middle row) and Mini Micron 77 (bottom row and top right) in a tea field recovering from pruning.

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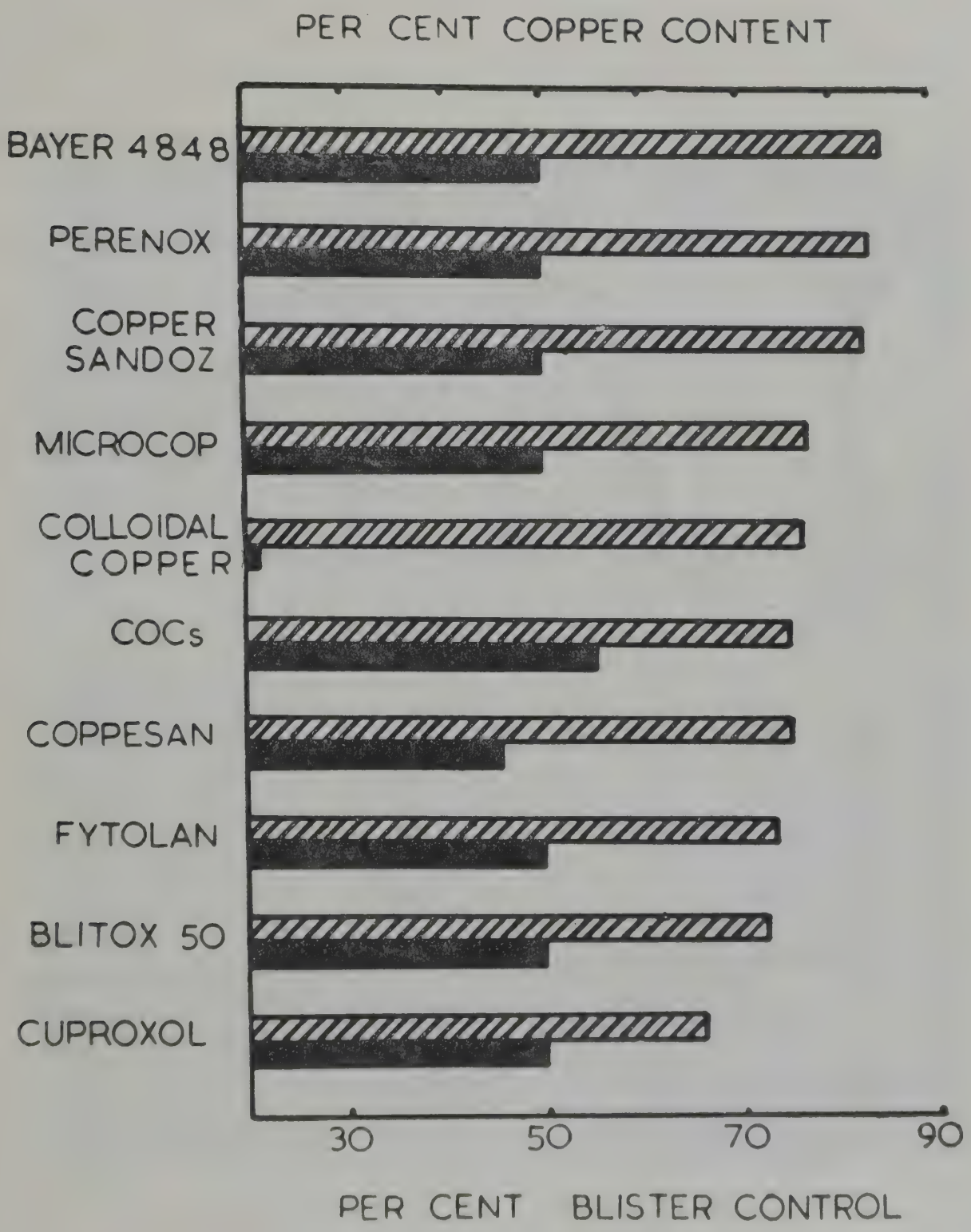
Fig. 1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MICROCOP
COLLOIDAL COPPER
COCs
COPPESAN
FYTOLAN
BLITOX 50
CUPROXOL
30
50
70
90
PER CENT BLISTER CONTROL

Fig. 2

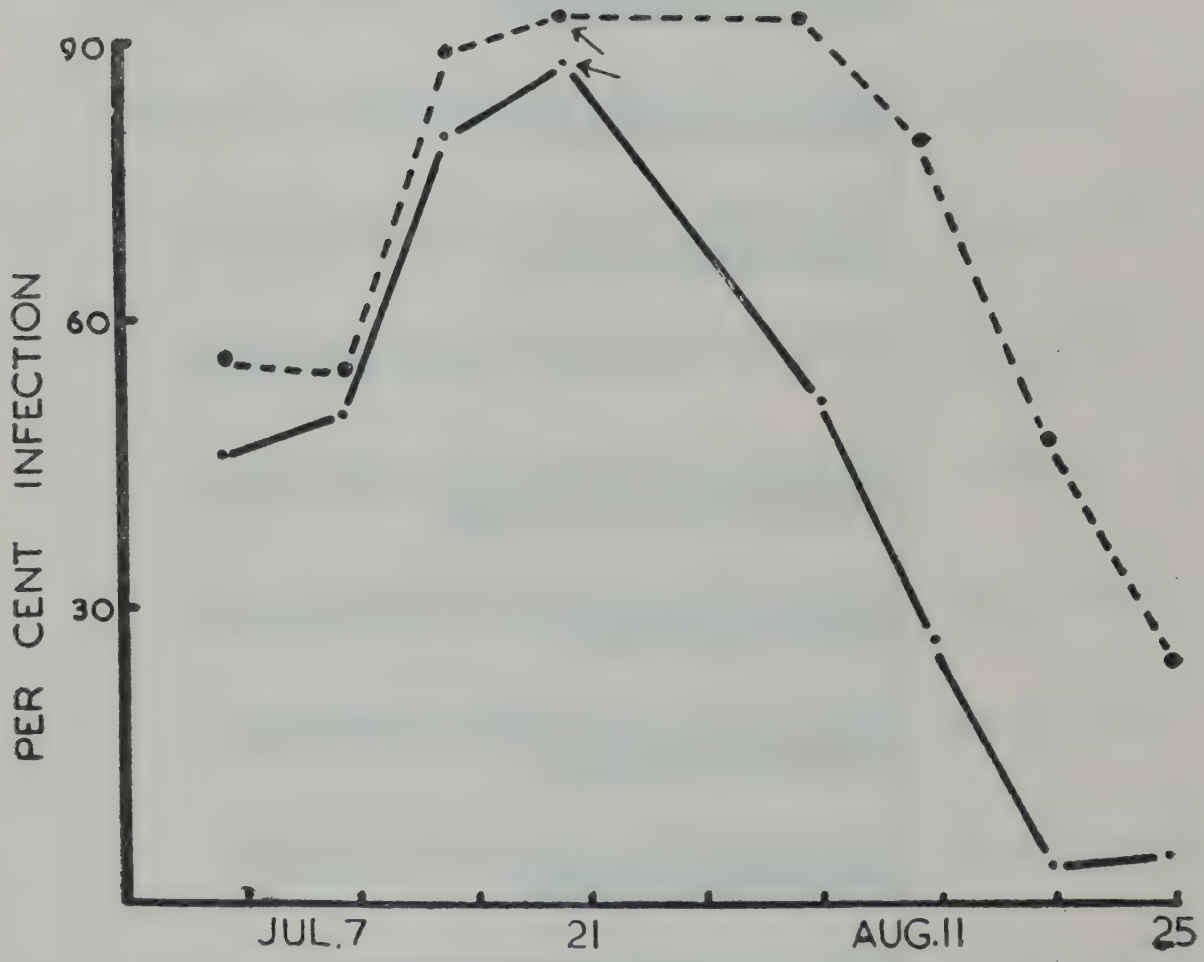


Fig. 3

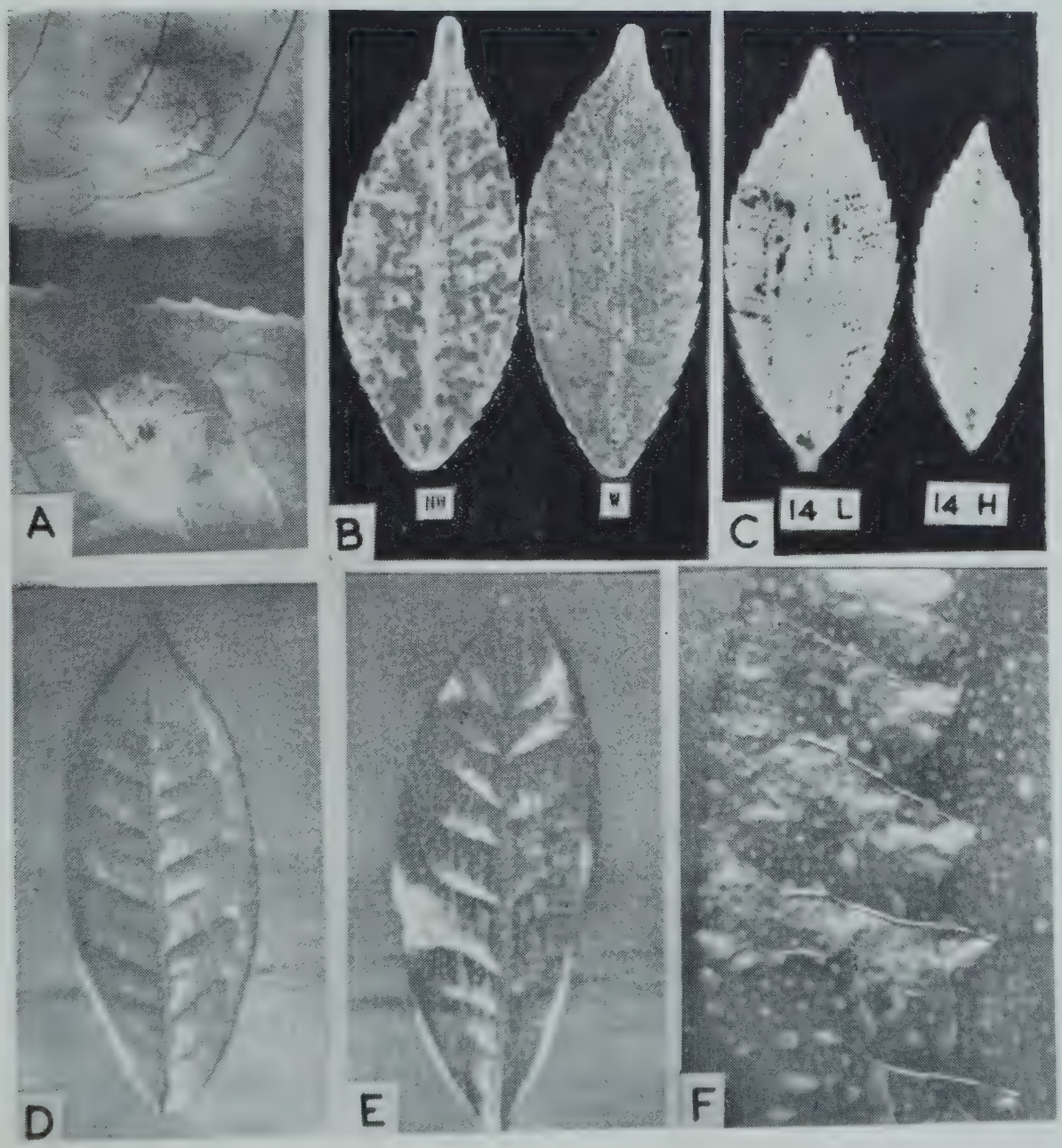
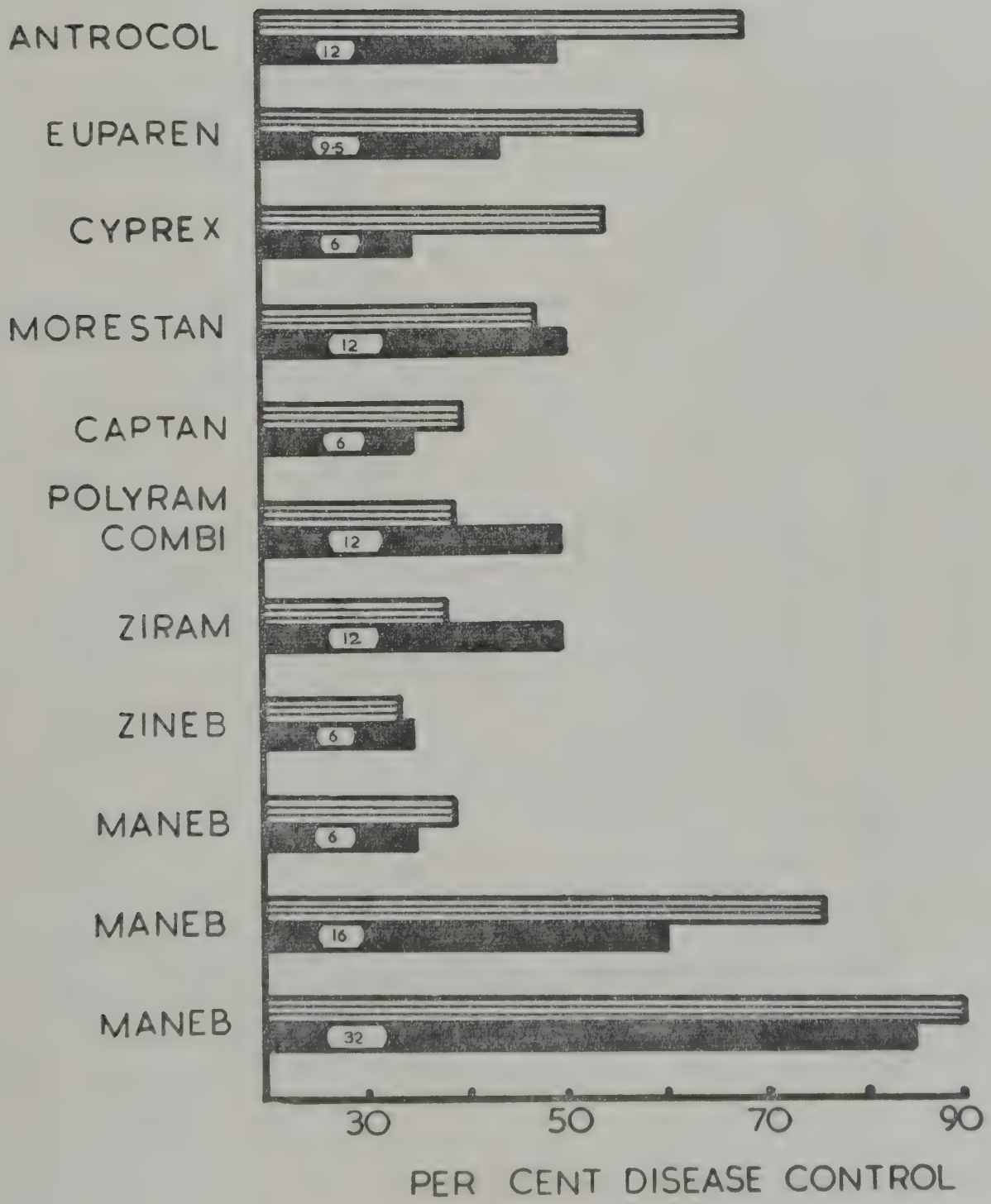


Fig. 4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EUPAREN
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CYPREX
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MORESTAN
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CAPTAN
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POLYRAM COMBI
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ZIRAM
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ZINEB
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MANEB
6
MANEB
16
MANEB
32
30
50
70
90
PER CENT DISEASE CONTROL

Fig. 5

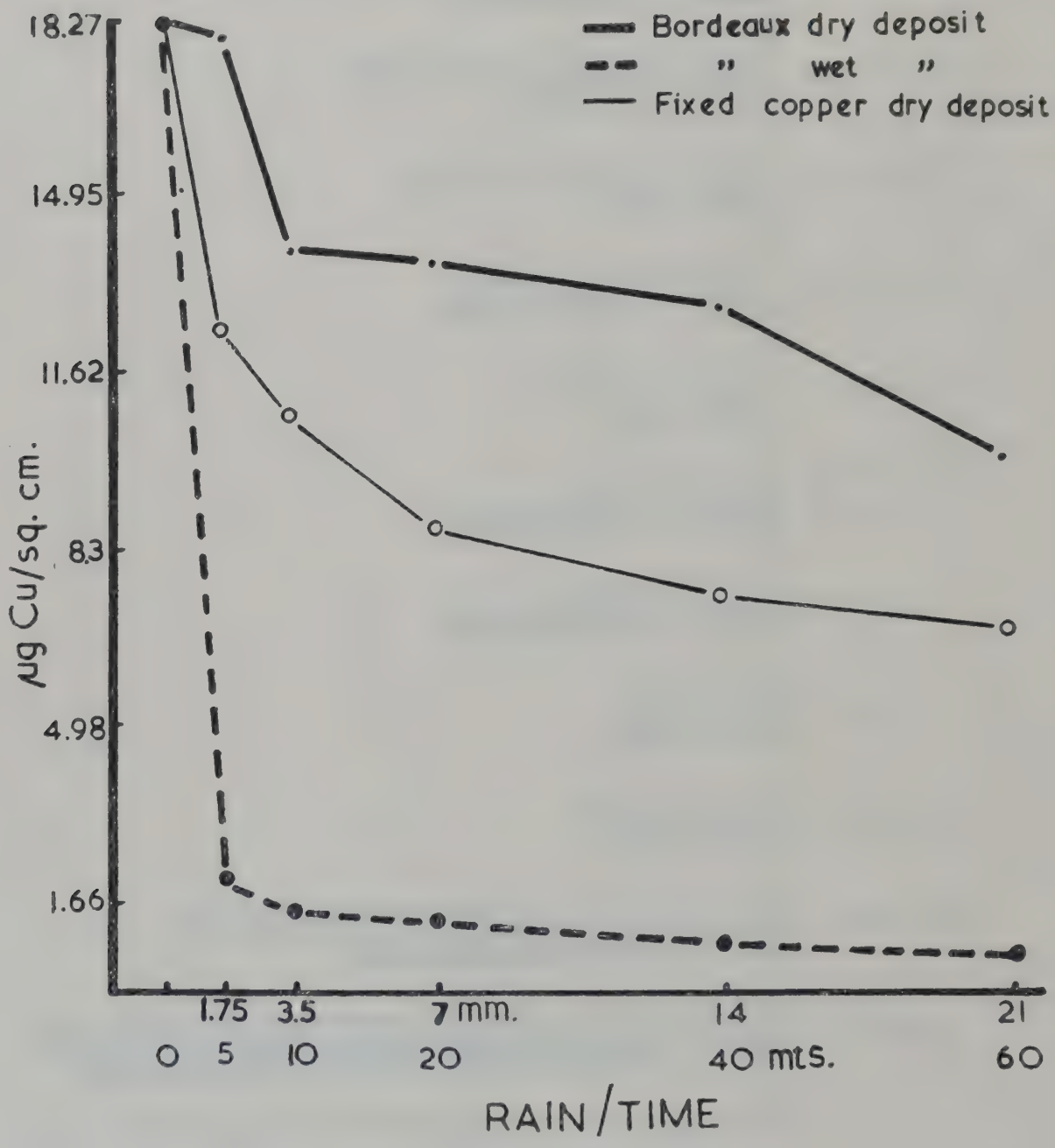
Bordeaux dry deposit
" wet "
Fixed copper dry deposit
18.27
14.95
11.62
8.3
4.98
1.66
µg Cu/sq. cm.
1.75
3.5
7 mm.
14
21
0
5
10
20
40 mts.
60
RAIN/TIME

Fig. 6

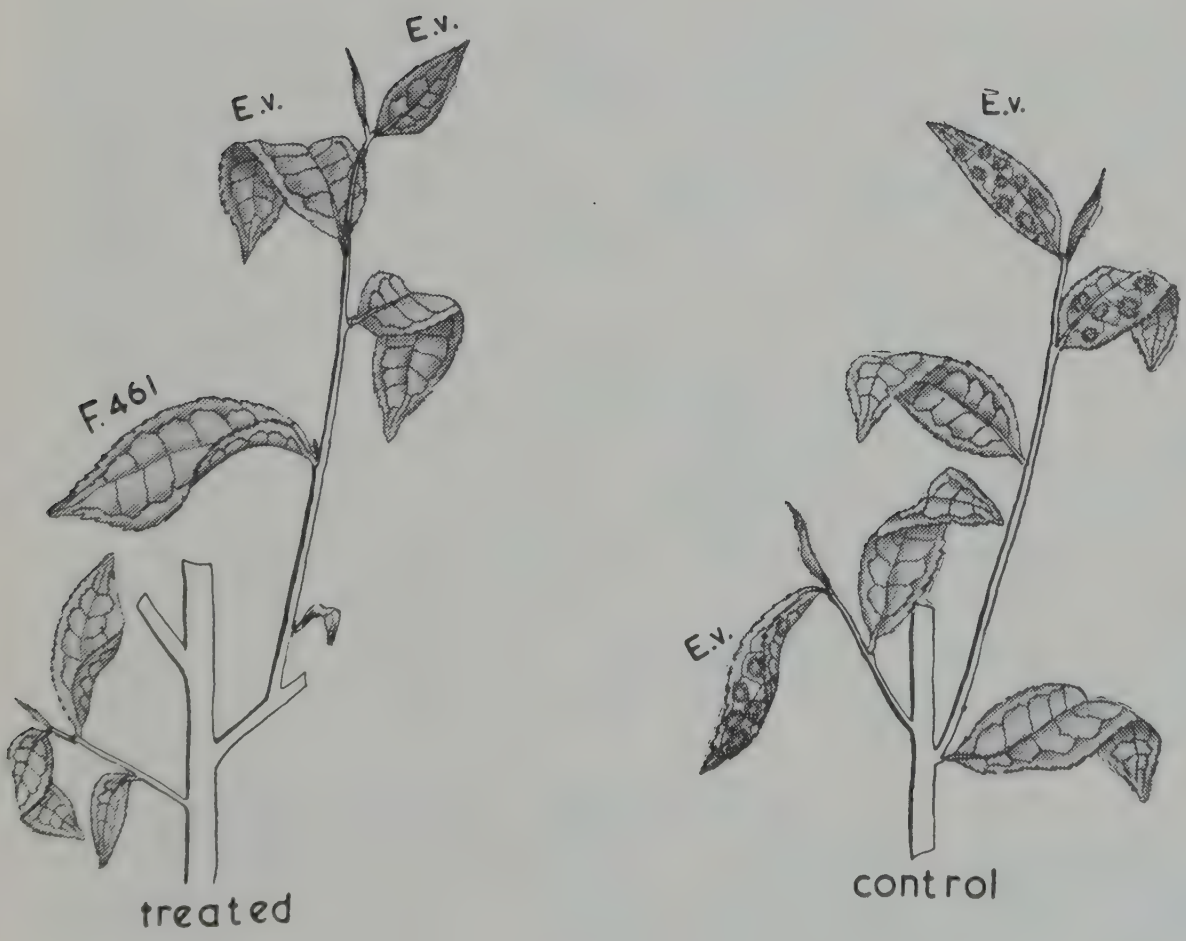

Fig. 7

Fig. 8

CLONAL SELECTION, A METHOD OF IMPROVEMENT OF TEA PLANTING MATERIAL

K. S. Venkataramani

Improved cultural practices can only partly help in rise in production efficiency in any horticultural enterprise. With indifferent planting material it is, indeed, difficult to achieve our objective of increasing production of quality tea. There is, therefore, a real need for improved planting material.

Plant breeding is no doubt a driving force and it is only with a systematic plant breeding programme that dramatic improvement in the planting stock could be achieved. The tea plant is predominantly a cross pollinator and, therefore, highly heterozygous. Breeding in the strict sense and evolution of pure line races in the polymorphic species *Camellia sinensis* are time consuming and beset with practical difficulties. Fortunately, nature has done all the breeding and a large variation in several important and desirable characters occurs from bush to bush in the existing tea plantations. Exploitation of such plant variability by careful selection for high yielding capacity, excellence of cup quality and fair resistance to drought and some important pests and diseases, and vegetative propagation of the selected bushes would, therefore, appear to offer a ready means of developing improved planting material in this perennial beverage crop. Our work during the last ten years has shown that clonal selection is a most rapid and rewarding method of improving the planting stock in tea. And, indeed, we have already released to the industry a few promising tea clones.

In this paper I shall attempt to give a very short account of the selection procedure. No attempt will be made to review the literature on this subject, but important publications detailing our investigations are listed at the end of the paper. Surely, selection has to be based on some principles and let us consider what they are.

The initial selection may be done by eye-judgement, examining the bushes for such features as recovery from pruning, wood formation, branching habit, flushing behaviour, colour and size of leaves, pubescence (hairiness) of buds and leaves. In brief, eye-judgement could be based on the following features:

(i) The number of stems per unit area of the bush should be high and their distribution should be uniform over the entire area of the bush.

(ii) The individual stems should not be thin and whippy, and it is also important that variation in thickness of the stems should not be great.

(iii) The size of the bush need not necessarily be large, but consistent with the factors detailed above, a bush showing a tendency to fill in quick with an early lateral spreading habit is desirable.

These characters can be determined just before or at the time of pruning, or in the first year from the prune.

The following further essential features have to be examined for:

(iv) It is obvious that the greater the number of buds per stem, the greater the density of the shoots is. In other words, the density of plucking points per unit area should be high (Plate 1, fig. 1).

(v) Uneven growth of shoots is not desirable and it is, therefore, necessary to select for evenness of bud-break and growth of shoots.

(vi) The main branch and the primaries developing from them after a prune should have an orthotropic growth habit (i. e. straight or erect growth) and not plagiotropic (i. e. oblique or horizontally spreading) habit (Text-fig. 1; Plate 1, figs. 3 and 4). Bushes with orthotropic growth habit and early secondary lateral branching appear to be high yielders. Rooting of cuttings derived from othotropic and plagiotropic shoots of a tea bush is practically the same, but shoot growth exhibits important differences. Cuttings from orthotropic shoots produce vigorous axillary shoots, while those from the plagiotropic shoots develop axillary shoots growing at an angle from the main axis, exhibiting effects of polarity (topophysis). This is more marked in some clones than in others.

(vii) If the above mentioned characters are present, one could then look for the size of the flush. Leaf size varies considerably (Plate 1, fig. 7). The bigger the leaf, the larger the weight of the shoot and hence greater the yield.

(viii) There seems to be a relationship between the colour of the leaf and cup quality, light coloured leaves generally producing better teas than the dark coloured ones. We shall refer to this again in a later part of the paper.

(ix) Selection may also be made for pubescence (hairiness) of buds and leaves. A selection with pubescent flush generally produces tea with better quality than one with glabrous (non-hairy) flush (Plate 1, figs. 5 and 6). This is definitely so in the case of selections with dark coloured flush, but not invariably with all light leaved selections. The results of our observations are presented elsewhere in this paper but it may be pertinent to point out here that highly pubescent flush is not satisfactory for CTC manufacture.

(x) The rooting character of tea clones is inherent to a great extent, and three kinds of root systems, namely, (a) shallow or horizontal, (b) vertical and (c) intermediate, are commonly known. In the shallow or horizontal root system, all roots develop at the surface and run almost parallel to the ground. Such a root system is obviously undesirable in a perennial rain-fed crop like tea. In the so called vertical system, one of the roots tends to go down almost vertically, gradually thickening and functioning as a tap root This kind is met with only in a very small percentage of the selections. The third, namely, the intermediate root system, is the one most commonly come across and in it at least one of the roots grows at an angle of 30° to 45° from the horizontal and penetrates deep into the soil. Selection for the kind of root system is, therefore, important.

Similarly, clonal variations are found in the ease with which cuttings root. Cuttings of some selections root readily, while those of some others only with difficulty. It is advantageous to select easy rooting clones.

(xi) Tea bushes showing varying degrees of resistance to blister blight and other diseases, pests and drought are no doubt seen in the field. Resistance to these factors may be examined for in the field at the time of selection. Resistance to pests and diseases, however, should not be the sole criterion for selection. We know that in the case of blister blight, resistance to the disease could break down, or to be more precise the fungus may mutate and produce physiologic races which could infect the so called resistant bush and its clonal progeny. This has actually happened in tea in southern India.

There is also an indication that some vigorous growing selections are able to resist the attacks of root-knot eelworm in the nursery. We are examining this question further, but we are mentioning this as a matter of interest.

(xii) Yield: It is impossible to predict the exact yield which a particular selection would give at any one situation without routine clonal planting, plucking and manufacture But, the potentiality of a selection for producing a good crop could be gauged by determining the individual bush yield and then converting this into yield per unit area during the period of test, say 3 to 6 months. Yield per unit area is important. It is a fallacy to calculate the potential yield of a selection by multiplying the individual bush yield by the number of bushes planted in a hectare Let us suppose that in a field planted 1.2 m. by 1.2 m , accommodating 6669 bushes in a hectare a large and spreading bush with a surface area of 3 sq. m. is selected, it is obviously impossible to pack 6669 such large bushes within a space of a hectare.

The cropping capacity of a tea bush does not always bear a direct relationship with the size of the bush. A big bush need not necessarily yield a heavy crop. Similarly, the small size of a bush need not necessarily mean that it is a poor yielder. As already mentioned, yield is correlated with the branching habit and flushing behaviour of the bush. There is tremendous variation in the yielding capacity of individual tea bushes in a plantation and estimates have shown that even in apparently uniform sections of tea fields, planted with seedling material, a small percentage of the bushes yields the greater part of the produce obtained. This is illustrated in Text.fig. 2; should all bushes have a similar yield capacity, then the yield curve will be a straight line ('Ideal efficiency'), but the field efficiency is never ideal and when yields are plotted against bush population, a concave curve is obtained. The average of three of our sample surveys for variation in yield is presented in table 1 and these data led us to think that initial selection for yield potential would be useful.

Table 1: Variation in yield

Bush population %	Yield %	
	Poor yielders	Good yielders
5	1	13
15	4	31
25	9	45

In selection for yield it would be useful to compare the yield per unit area of plucking surface of the selected bush with the yield per unit area of the field during the period of experimentation (at least 3 continuous months). The ratio of these figures is termed 'yield potential' - the greater the figure is, the greater the potentiality for yield. This may be illustrated as follows:

$$\text{Yield potential (YP)} = \frac{\text{Bush yield per unit area}}{\text{Field yield per unit area}}$$

YP = 1, if field efficiency is ideal

YP = <1, if a selection is a low yielder

YP = >1, if a selection is a high yielder

It is important to note that the yield potential data will have some meaning only if selections are made in uniform sections of tea fields where the cultural practices are standardised and where vacancies and infillings do not occur. It is, therefore, the responsibility of the tea selectionist to ensure that he is making the selections under appropriate conditions.

We have already mentioned that the yielding capacity of a tea bush is not always dependent on the size of the bush and that small sized bushes may produce good yields under certain circumstances. To cite a few examples, two of our selections with large surface areas of 4.371 and 4 836 sq. m. have low yield potentials of 1.7 and 1.9 respectively. Two other selections with small surface areas of 1.488 and 1.209 sq. m. have high yield potentials of 4.9 and 4.8 respectively. Our observations so far show that there is a tremendous variation in the yielding capacity of the bushes in a tea field, ranging from 1.2 to 6.0 times the average field yield during the period of investigation. The majority of the selections initially marked out on the basis of eye-judgement have yield potential falling within the range of 2 0 to 3.5. Initially, therefore, bushes with yield potential of more than 2 are marked out for further tests.

We must emphasize once again that the yield potential data will only give an indication whether or not a selection is likely to produce a good crop. Final yield tests of a selection (or clone) must be based on data obtained from clonal plots. If one has to ensure that a particular clone will do well in the different parts of a tea growing area, or in different tea tracts, that clone must be put to test in the different situations.

(xiii) Selection for overall quality is important. Tea bushes in the field vary widely with respect to this character. Shoots from some bushes produce only mediocre teas. Shoots from some bushes do not ferment at all. or they take a long time to ferment, say 4 hours or more from the start of the first roll. However good such bushes may be from the point of view of other characters, selection, large scale multiplication and use of such clones may result in an overall deterioration of quality of the produce from an estate.

Miniature manufacture of leaf harvested from individual bushes with the help of a meat mincer, a miniature orthodox roller or a mini-CTC machine and an electrically operated miniature dryer (plate 4, figs. 1 to 6) gives a fair indication of the inherent quality.

As far as overall quality is concerned, bushes with light coloured flush, though the mature leaf may be dark in colour, produce acceptable teas. Pubescence (hairs) of the bud and the first leaf has a bearing on overall quality, but not invariably so with all light leaved selections. The results of our tests are presented in table 2.

Table 2: Summary of taster's valuation
Average for June, July, October, December and February (1964—1965)
Total marks for 10 selections - Max. marks possible = 100

Selection	Colour of leaf	Strength	Overall quality	Flavour
Dark green glabrous ...	57	59	44	43
Dark green pubescent ...	58	57	43	44
Light green glabrous ...	63	63	50	51
Light green pubescent ...	61	61	53	53
C D. @ 1% ...	2.31	2.7	2.59	2.67

Our recent findings show that pubescence is not a mere physical entity. The leaf hair contains certain chemical constituents which are responsible for the development of flavour. We discussed this in our last scientific conference and we would now like to mention that in the laboratory we could alter the overall quality of non-flavoury teas by addition of constituents extracted from the pubescence of flavoury teas.

There are also indications that pigmentation of the petiole and young leaves may have a bearing on quality, especially when it is associated with light leaved flush, although pigmentation by itself is not a very useful criterion for selection. Our preliminary findings are presented in table 3.

Table 3: Summary of taster's valuation
Average for August, September, October & December 1965
(Total marks for 8 selections - Max. marks possible = 80)

Selection	Infused leaf	Liquor			
		Colour	Strength	Quality	Flavour
Dark green pigmented	42	49	53	43	42
Dark green non-pigmented	37	50	51	39	40
Light green pigmented	53	53	57	49	48
Light green non-pigmented	43	51	51	44	41
C. D. @ 1%	1.91	1.98	1.45	1.39	1.28

Quality is an inherent character. Offsprings of bushes selected for quality at Coonoor on the Nilgiris have produced quality teas in the Anamallais at a much lower elevation. Elevation and season, of course, have their influence on quality. We also find that flush harvested from young plants, say about 2 years from planting or 3 years from cuttings, produce teas reasonably comparable with teas made from leaf harvested from the old parent bushes. Results presented in table 4 would illustrate this point.

Table 4: valuation of clonal teas of B/5/63

Source	Infused leaf	Liquor			
		Colour	strength	Quality	Flavour
Mother bush	10	7	7	8	8
2 year old bush	10	8	7	8	8
3 year old bush	10	7	8	8	9
4 year old bush	10	8	8	7	8
5 year old bush	10	9	8	8	8
6 year old bush	10	8	8	8	8

Maximum possible marks = 10

(xiv) Observations made in different zones on the Nilgiris and at the Tea Research Station in the Anamallais indicate that a particular selection could only be recommended for a definite combination of soil and climate. The lighter types are preferable to the darker ones for general planting, but the vegetative growth of such selections are strongly influenced by external conditions. Selections with dark mature foliage appear to possess a strong vegetative habit and they are very little subject to external circumstances.

Some of our high elevation selections perform well at mid-elevations and indeed, one of our clones 'Sundaram', formerly coded as B/5/63, thrives at elevations ranging from 900 to 2300 m.

We have examined several hundreds of tea bushes on estates on the Nilgiris, which offered us facilities for initiating our project on plant improvement and we consider the following twenty-three tea clones promising and worthy of extended trials on estates:

B/4/141, B/4/142, B/4/198, B/6/7, B/6/10, B/6/24, B/6/25, B/6/34, B/6/36, B/6/61, B/6/62, B/6/127, B/6/129, B/6/174, B/6/182; B/6/203, S/6/99, B/5/214, CR/11/35, CR/11/46, SP/4/5, SP/4/6 and B/5/63 or 'Sundaram'.

We have already mentioned that quality is an inherent character and to a large extent is transmitted to the clonal progeny. This reflects on the valuations of teas, and selections made for quality on the Nilgiris have fared well in the Anamallais as could be seen from the valuations of experimental teas presented in table 5.

Table 5: Nominal valuation of experimental clonal teas made in July 1970 in the Anamallais.

Clone	Rs. per kg.
B/5/63	10-75
S/6/99	10-50
B/4/142	10-50
B/6/62	10-50
B/4/141	10-25
SP/4/5	10-00
B/6/36	10-00
B/4/198	10-00
B/6/61	9-50
B/6/10	9-00
B/6/34	7-00
District average	6-36
Highest in the district	7-76

The data presented above should not be considered as absolute values; they are only indications of the potential value of clones selected for quality.

These, in brief, are the general principles on which 'parent' or 'mother' bush selection is based in our plant improvement programme. We must, however, emphasize on the fact that a 'mother' bush is selected as a starting point for building up a clone. Mother bush selection, therefore, is a means and no end.

We will not, at this stage, present details of the vegetative propagation of tea by means of a leaf and internode cuttings. The propagation technique is now standardized and we have already discussed it in great detail in several of our publications. The illustrations in Plates 2 and 3 give a graphic account of the procedure adopted for tea clonal propagation in southern India.

We have now presented a gist of our work and have explained how the planting stock could be improved by clonal selection. We trust you will appreciate that the use of the right kind of planting material alone in replanting and future plantings will have far reaching consequences.

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Explanation of Plates 1 to 5

PLATE 1

Fig. 1 : A portion of a tea bush showing a large number of plucking points in a unit area.

Fig. 2 : A portion of a tea bush with poor distribution of plucking points.

Fig. 3 : Orthotropic growth habit - note the shoots growing vertically.

Fig. 4 : Plagiotropic growth habit - the primary shoots grow horizontally or in an oblique manner.

Fig. 5 : The buds and leaves are glabrous (non-hairy).

Fig. 6 : The buds and leaves are pubescent (hairy).

Fig. 7 : Tea leaves of different sizes.

PLATE 2

Fig. 1 : High shade in a tea nursery ; individual beds are covered with coir-matting.

Fig. 2 : Cuttings put out in thumb pots and the bed covered with coir mat.

Fig. 3 : Propagation bed covered with polythene.

Fig. 4 : Polythene cloche covered with coir matting.

Fig. 5 : A view of a polythene cloche.

Fig. 6 & 7 : Views of propagation beds showing cuttings.

Fig. 8 : Young tea plants in polythene sleeves.

PLATE 3

Fig. 1 ; A tea cutting with normal callus development at the basal end.

Fig. 2 : Note the root development from the basal end of the cutting.

Fig. 3 : A cutting with excessive callus growth, an undesirable feature.

Fig. 4 : Root development from the callus tissue.

Fig. 5: Cutting showing an ideal root system.

Fig. 6 & 7: Seven months old plants raised from cuttings.

Fig. 8: Polythene bags for planting tea cuttings If bags are used, instead of sleeves open at both ends, attention must be paid to drainage : holes should be punched as shown in the picture.

PLATE 4

Fig. 1 ; A mincer used in miniature manufacture.

Fig. 2: A miniature trough withering unit.

Fig. 3: A mini CTC machine.

Fig. 4: A miniature orthodox roller.

Fig. 5: A view of the rollers of a mini-CTC machine.

Fig. 6: An electrically operated miniature dryer.

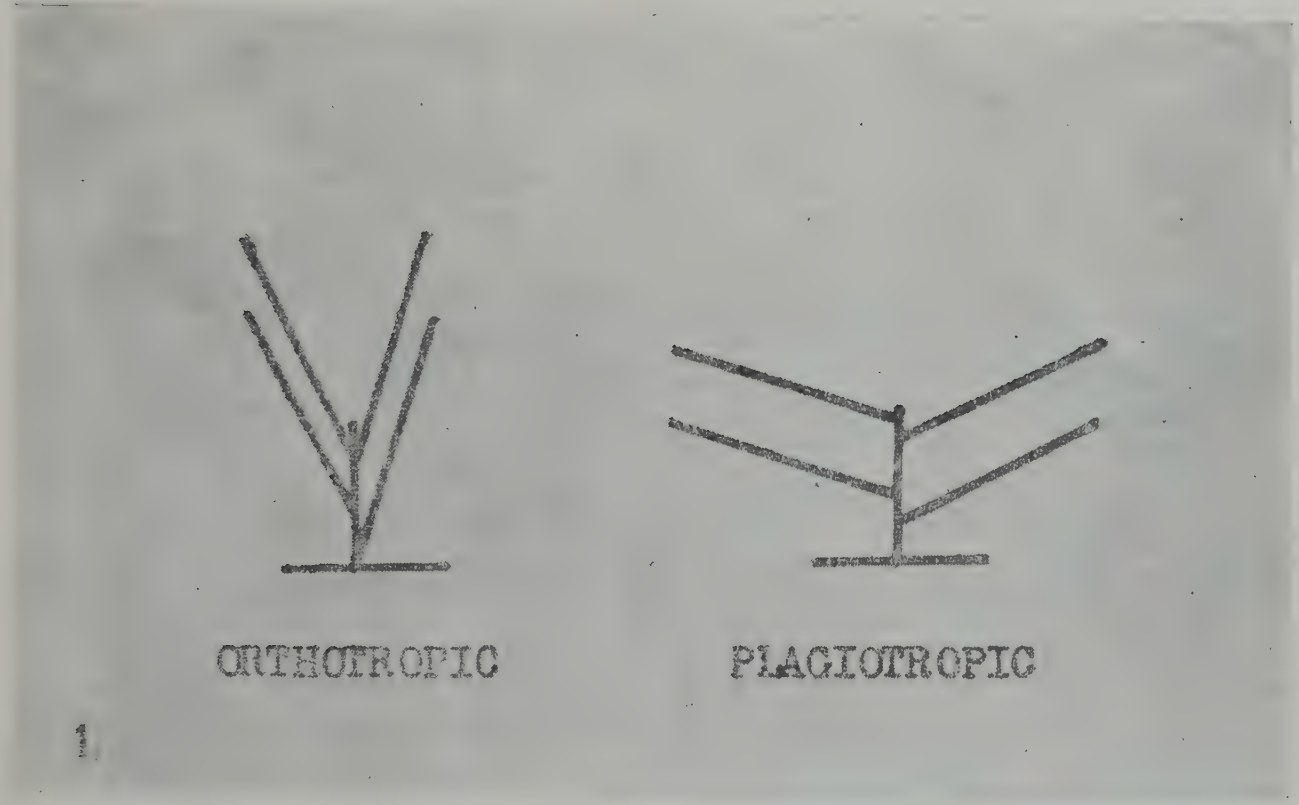
PLATE 5

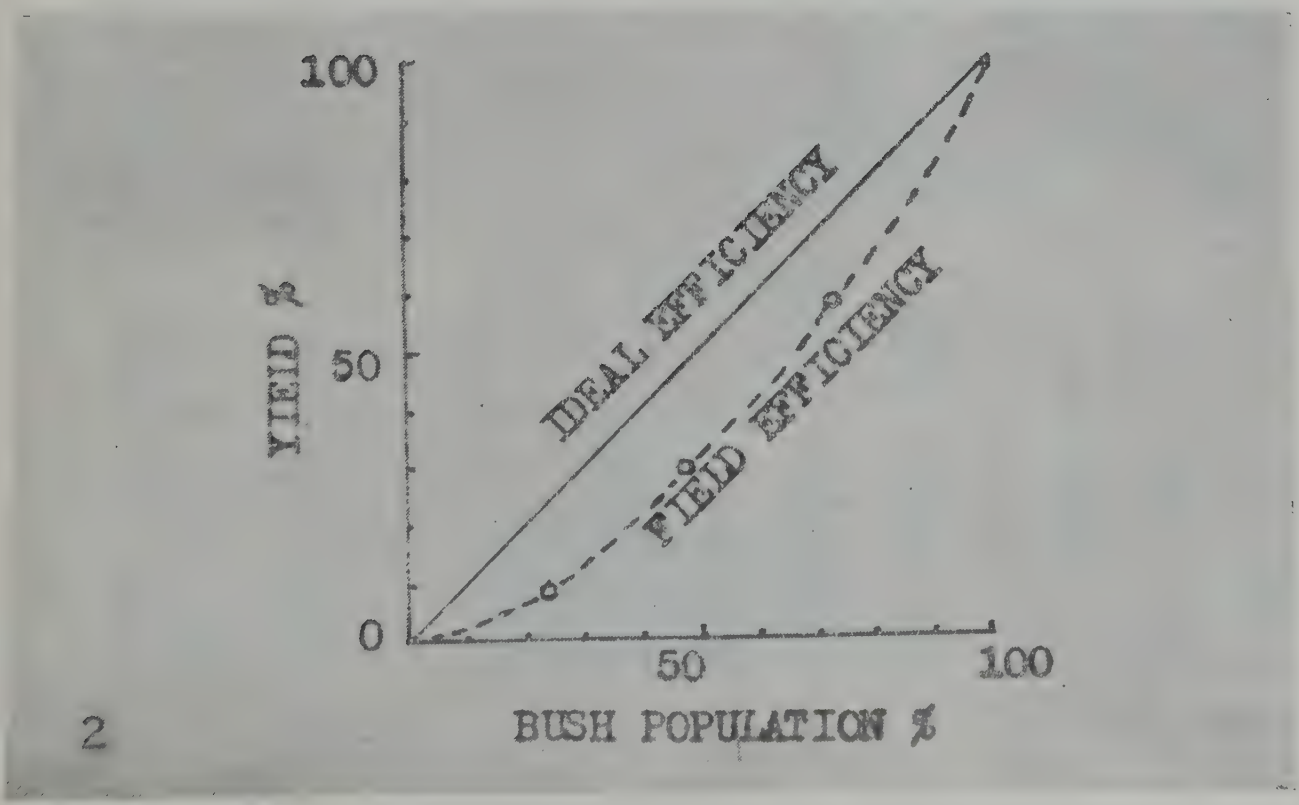
Fig. 1: A row of two-year old plants of the tea clone 'Sundaram'.

Fig. 2 : A view of a four-year old field.

Fig. 3 & 4: Actively growing shoots.

Fig. 5: A flush shoot.





Text - Figs. 1 and 2

K. S. Venkataramani

" Clonal Selection, A Method of Improvement of Tea Planting Material "

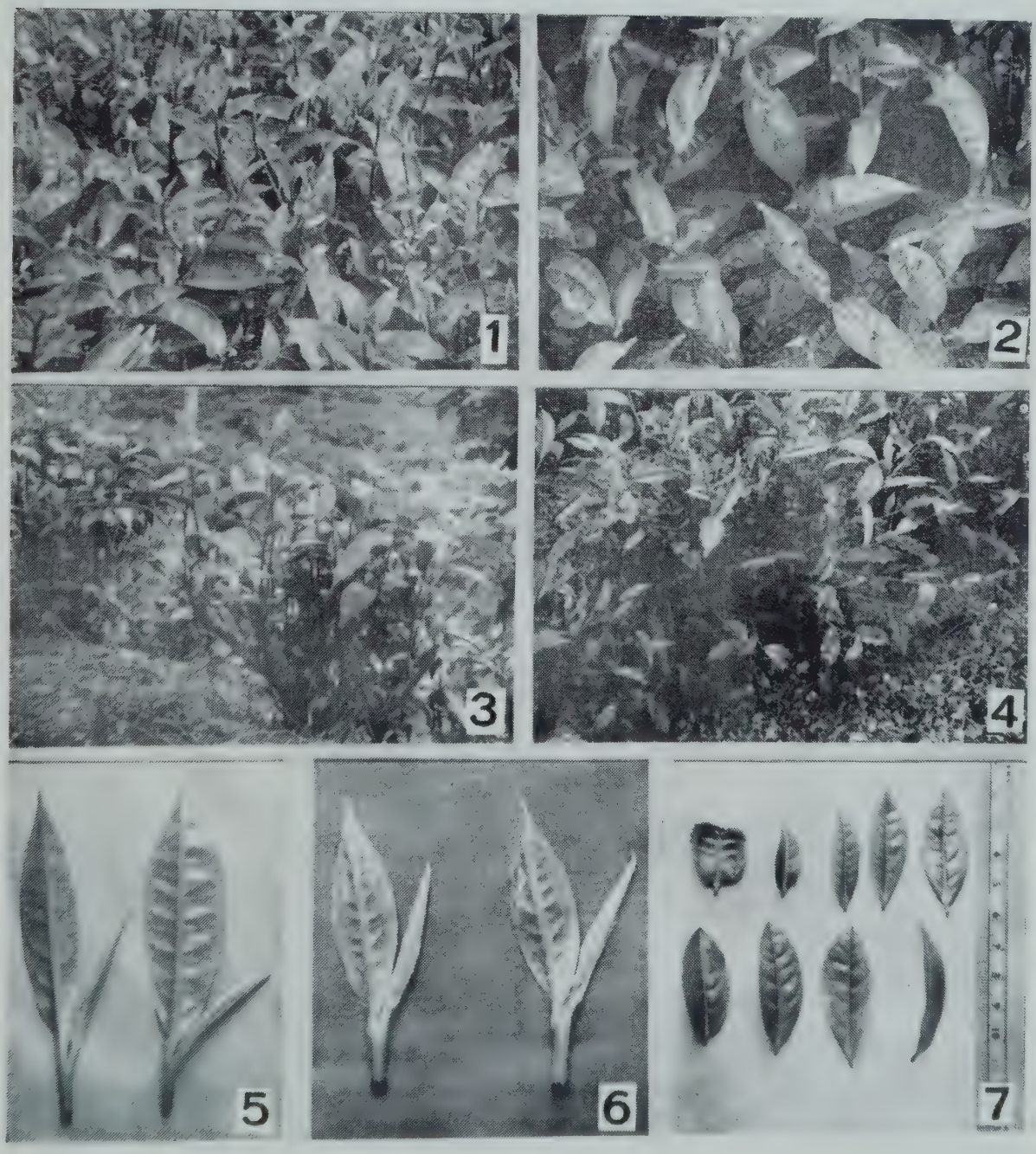


Plate 1

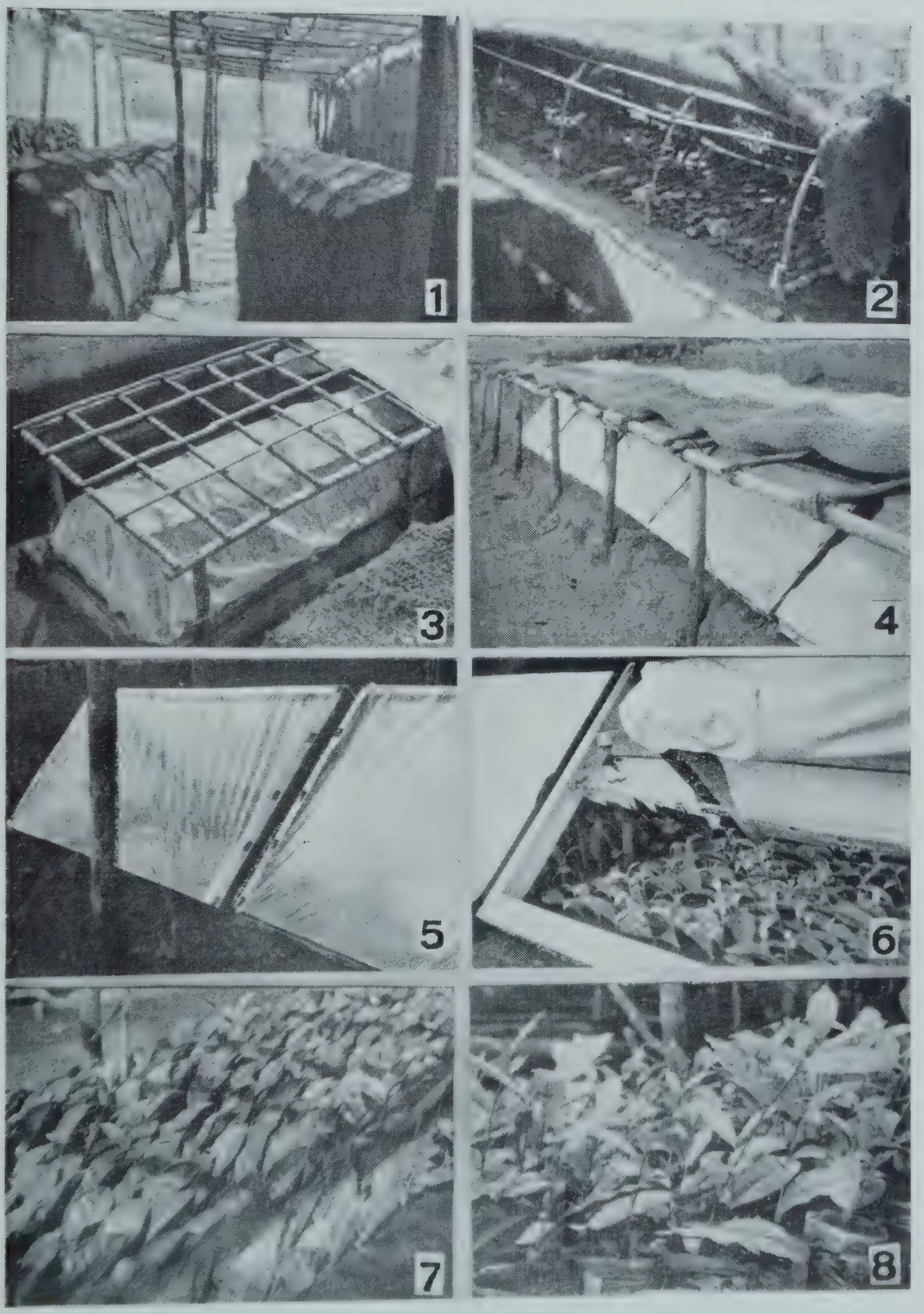


Plate 2

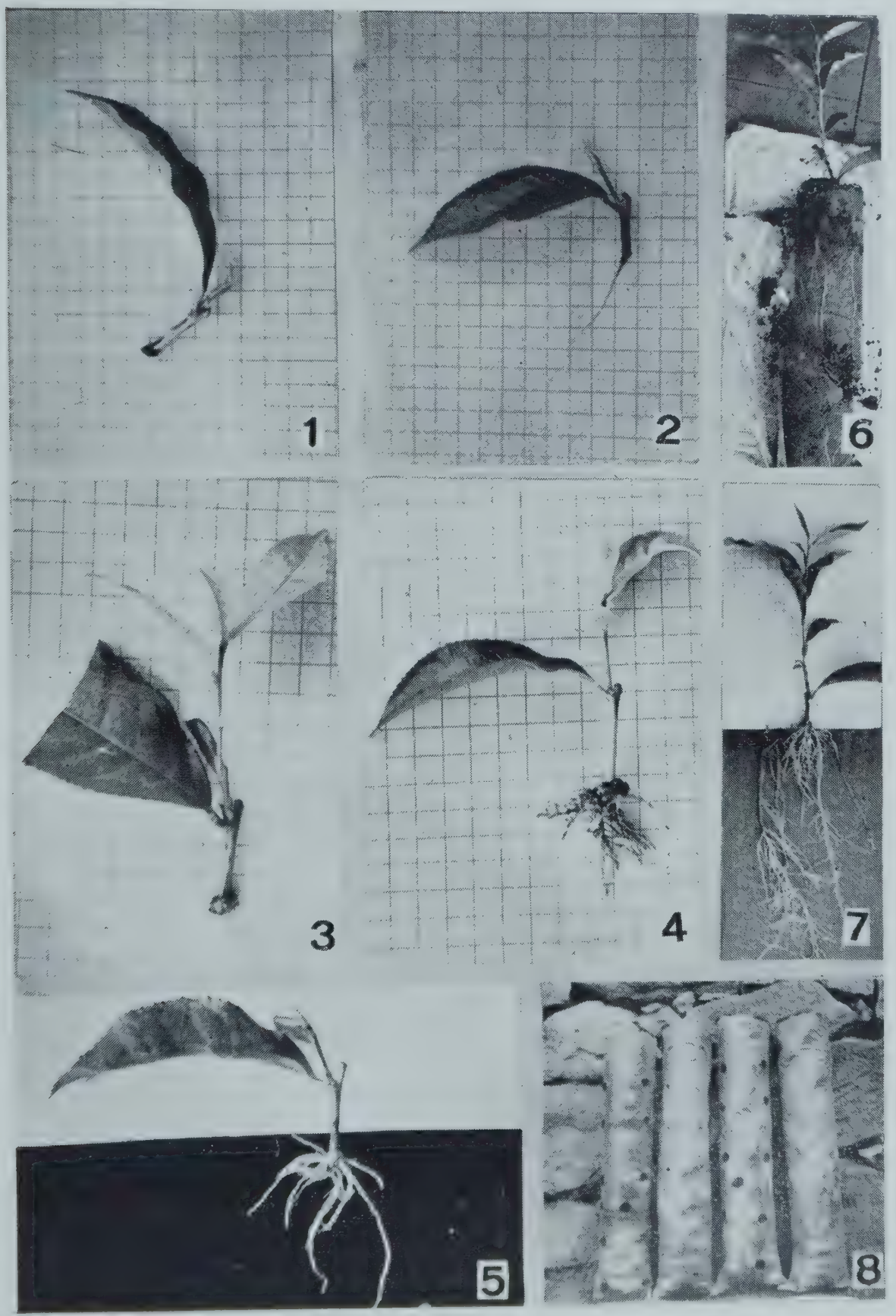


Plate 3

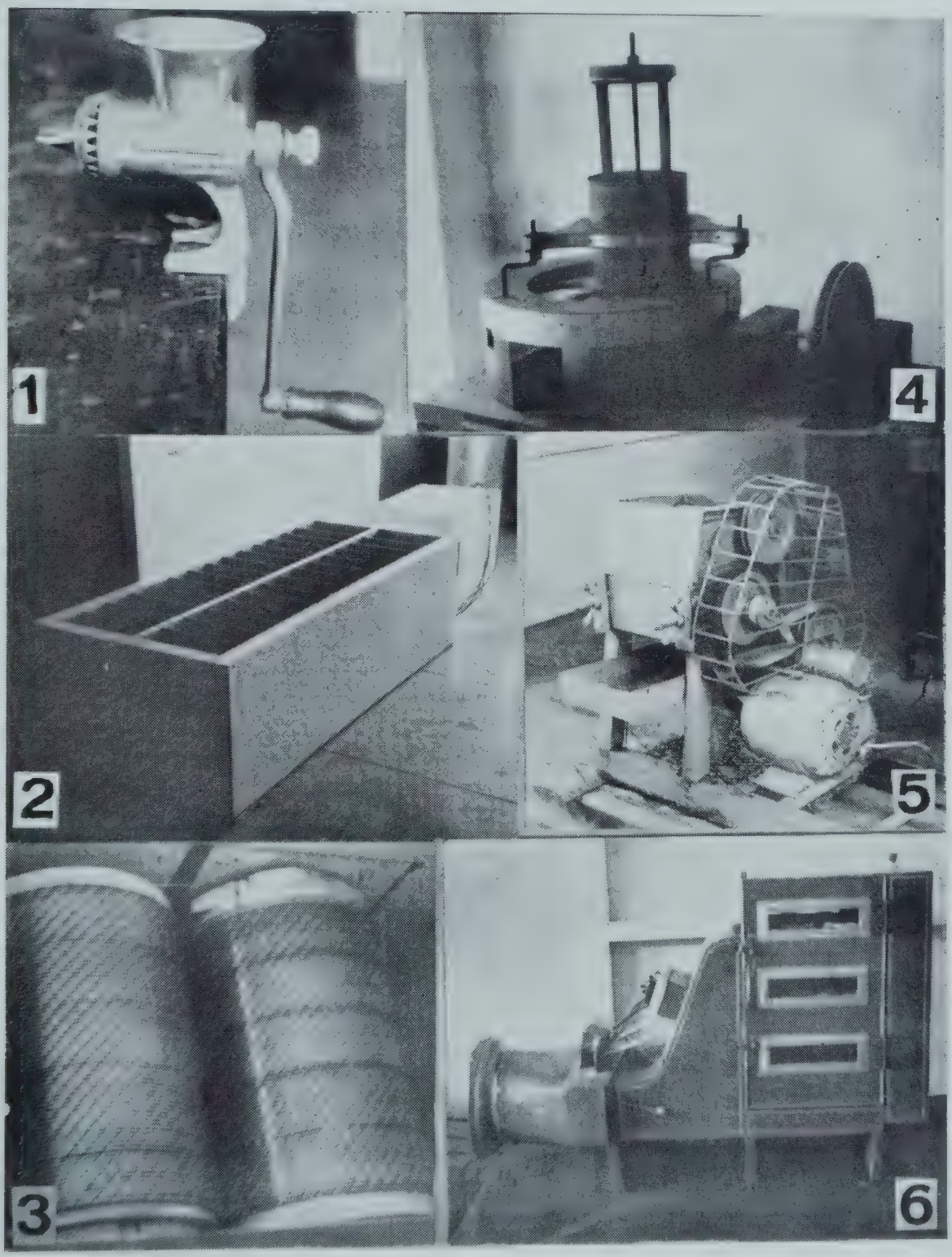


Plate 4

Plate 5

DISCUSSION

CHAIRMAN: How far have you progressed with chemical weed control in Ceylon?

DR MANIPURA: The experimental work on weedicides in Ceylon was started much later than in South India as stated by Dr. Venkataramani. We are conducting experiments on a number of weedicides and at the moment estates are using Gramoxone quite widely and also other residual herbicides like Karmex and to some extent Simazine and on a limited scale 2, 4-D. As mentioned by Dr. Venkataramani if chemical weedkillers are used cautiously and at the proper time they could be quite economical when compared to manual weed control.

CHAIRMAN: Have you overcome the Couch problem?

DR. MANIPURA: We have tried dalapon on Couch. In Ceylon most of the planters aim at eradicating Couch, rather than control and for eradication dalapon has been effective. In areas marked for replanting Methyl bromide fumigation has been found effective for eradication of Couch. This is, of course, not a solution in standing tea.

CHAIRMAN: Thank you, Dr. Manipura.

CHAIRMAN: Mr. Grice, how are you handling the thatch problem in Assam?

MR. GRICE: In Assam we find that we can control all the weeds with a few weedkillers. Thatch is found to be effectively controlled with dalapon at rates lower than what is recommended in South India, we recommend 3 kg/ha (which is roughly 3 lb/acre) and 10 days after the application of dalapon a follow up application of Gramoxone, at 1 litre in 200 litres of water is given and we find that it is very effective. For broad leaved weeds 2, 4-D followed by Gramoxone is recommended and with these three chemicals we could keep all the weeds that are found in North East India under control. I must, however, stress that the timing of spraying and use of proper equipment are important. I would like to pose a question here. Have you had any problem of soil erosion following complete control of weeds with chemicals?

DR. VENKATARAMANI: From visual observations we do not believe that soil erosion is a problem. Chemical weed control alone should not be the answer for eradicating grasses. Chemical weed control should be accompanied by good husbandry.

MR. GRICE: This does not cover young tea.

DR. VENKATARAMANI: I agree, but in young tea our recommendation is to keep the soil covered with mulch. Our aim on hill slopes is not weed eradication but weed control. We do not wish to see a bare soil.

CHAIRMAN: May I ask whether you recommend any mechanical auxilliary exercise, such as hoeing after application of dalapon. When I was recently in Assam I was informed that you recommend hoeing 6 days after dalapon application.

MR. GRICE: No, it is to be either mechanical control or chemical control, but not both.

MR. MASSEY: Would not chemical weed eradication mean that the organic matter which is normally returned by the weeds is lost?

DR. VENKATARAMANI: The broad leaf weeds leave less than 1000 lb. of dry vegetable litter per acre annually. This is not very much when we consider the fact that the dry leaf litter returned by the tea weighs approximately 2 tons per acre and the litter from Grevillea shade trees amounts to 4.5 tons. Therefore, no one need fear that the organic matter status of the soil will be adversely affected.

MR. KANKANI: Is there any danger from the long term use of chemical weedkillers to tea?

DR. VENKATARAMANI: From our limited experience over the last ten years and from what we read in literature we do not think there is any danger in using chemical weedkillers. But it is important that our recommendations are strictly adhered to and the dosage is not grossly exceeded.

MR. PUNJA: In Kenya they recommend not only weed control but complete weed elimination. What does Dr. Venkataramani recommend to my fellow planters here on this aspect?

DR. VENKATARAMANI: As I said weed control should be accompanied by good husbandry and if you can ensure good cultural practice even complete elimination of weed will not be harmful. The most important point arising from the Kenya recommendations is that there should be no soil disturbance because there is greater response to phosphates when weed control is achieved without soil disturance. This is because feeder roots develop at the surface and they are able to utilize the phosphates applied.

MR. PUNJA: All these years we felt that the presence of some weeds in tea is useful, not only with regard to stopping erosion, but in other ways. What you now say is that complete elimination of weeds followed by good cultural practice will be beneficial.

DR. VENKATARAMANI: Yes. Weeds are not directly beneficial to the tea bushes in any way. A reasonable cover of soft weeds, when they do not compete with tea bushes, help in the prevention of soil erosion on hill slopes.

MR. WARUSAVITARANE: In Ceylon we find that termites became a problem in tea fields continually sprayed with Gramoxone.

DR. VENKATARAMANI: We have not so far had this problem in tea even in areas where Gramoxone has been intensively used.

CHAIRMAN: Any more points?

CHAIRMAN: We will now discuss Mr. Ranganathan's second paper on genesis of fertilizer recommendation in tea.

MR. RAGHAVAN NAIR: It is well recognised that the uptake of zinc, magnesium, etc., will depend on the pH of the soil. Mr. Ranganathan mentioned that 69 per cent of the High Range Soils have a pH below 5 and only 31 per cent have a pH above 5. Under these circumstances what should be our approach to the problem? Should we spray zinc sulphate and magnesium sulphate or try to solve the problem by some other means? Mr. Ranganathan also stated that the drop in

the pH of the jungle soil was much less than that in tea soils. My own experiments over the last 10 years show that there is absolutely no response to potassium above 40 lb. per acre.

MR. RANGANATHAN: The acidity of the soil is due to hydrogen ions replacing potassium, magnesium and other cations. Therefore, acidic soils will contain low potassium, magnesium and other similar cations. Hence the basic approach should be to displace the hydrogen ions with cations like potassium, magnesium and calcium. There does not appear to be any other approach. We have to saturate the soil with cations. We should also aim at increasing the exchangeable potassium content in soil and retention of potassium by reducing the acidity and our recommendation is to increase the pH to about 5 whenever it is low and maintain it at that level.

MR. GEORGE VARGHESE: Could you please tell us what your recommendations are regarding the application of lime?

MR. RANGANATHAN: The quantity of lime applied will depend on the initial pH of the soil and texture. In general, we suggest that for soils with a pH value of below 4.5 two metric tonnes be applied per hectare, and for soils between 4.5 and 4.9 one metric tonne, once in a pruning cycle.

MR SAVUR: What are your recommendations with regard to phosphates?

MR. RANGANATHAN: Tea roots are able to take phosphate by mere contact with the phosphate particles by a phenomenon known as contact exchange. That is why in our soils where the feeder root development is not on the surface we recommend placement of phosphatic fertilizers. At the moment we feel that 30 to 40 lb. of P_2O_5 per acre are adequate.

DR. VENKATA RAM: Mr Chairman, may I ask one question of Mr. Raghavan Nair? Is he asking for recommendations where we will have to protect the soil pH, the soil potash, the soil nitrogen, etc., and forget the tea crop or are we in commercial business to exploit the tea crop and do what is appropriate at different stages for correcting soil acidity and nutrient status?

MR RAGHAVAN NAIR: I will repeat one sentence of Mr. Ranganathan, namely, that the nutrient holding capacity of the soil depends on its organic matter. Dr. Venkataramani mentioned that the leaf litter from tea alone amounts to 2 tons per acre annually and from shade trees 4½ tons approximately. I do not say that we can maintain the soil in its pristine purity but we could maintain it in its old form. Mr. Ranganathan showed how the pH of the jungle soil does not fall very sharply when compared to the tea soil.

DR. VENKATARAMANI: May I interrupt? We are not applying any fertilizer to the jungle soil. In tea in Mysore from 1940 to 1950 they were applying 40 lb. N per acre in the form of ammonium sulphate. From 1950 onwards people have been very happy in putting out large quantities of ammonium sulphate to increase the yields. This is the reason why there is a change in the pH of tea soils.

MR. RAGHAVAN NAIR: This is all the more reason why we should maintain the organic matter status of the soil.

DR. VENKATARAMANI: How are we going to maintain the organic matter content at a higher level? There is always an equilibrium established in the organic matter status of tropical soils. Mr. Ranganathan has already given the details in his paper. Of course, our aim should not be to impoverish the soil and we realise that soil fertility should be maintained.

MR G. T. PANDIARAJ: Is the Scientific Department planning to develop soil maps for different regions.

DR. VENKATARAMANI: Yes sir, we are trying to do this, but you will appreciate that it will take quite some time.

CHAIRMAN: Any comments from Ceylon?

DR. MANIPURA: We have also found a fall in soil pH when sulphate of ammonia was continually used over very long periods. Much of the argument is that the jungle soils maintain the pH whereas in tea soils the pH goes down. This goes back to the old argument that we must return to nature. But, if we do that, how are we going to get these high yields? We are aware of this problem and we are tackling it by the use of lime, urea and calcium ammonium nitrate.

CHAIRMAN: Thank you very much.

MR. GRICE: In recent years we have found marked response to potash in the Siliguri area as well as Assam. For years we had been saying that we do not get any response and suddenly it has happened. The scientists who are working on this problem believe that when sulphate of ammonia is used over a number of years the soil acidity increases, leaching out the potash. Hence by large application of potash, 300 kg/ha, we are building up the level of potash. We are also suggesting the use of less acid forming nitrogenous fertilizer, such as urea.

DR. VENKATARAMANI: Yes, Sir, we are also recommending the use of CAN and Urea where large quantities of N are applied to tea, limiting the use of sulphate of ammonia to approximately 50% of the total N.

MR. ABRAHAM VARGHESE: Mr. Ranganathan mentioned that the efficiency of nitrogen differs with clones. Are you trying out all the different clones for their efficiency in utilizing nitrogen?

DR. VENKATARAMANI: We have just started some work on this subject. We have some information with regard to two clones, but it will be some time before we can make any firm recommendations.

CHAIRMAN: I think that was a very good question. That is something we want to know quickly. Have you any information in Ceylon?

DR. KULASEGARAM: We find that some of the clones are able to respond to larger quantities of nitrogen than others. Therefore, we are trying to review our fertilizer recommendations.

MR. SETHNA: What is the saturation point for nitrogen in Ceylon?

MR. WARUSAVITARANE: The saturation point is 600 lb. of N on 7500 lb. crop. We find boron deficiency in Ceylon. Is it a problem in South India?

DR. VENKATARAMANI: We have not observed boron deficiency in tea in South India, but we have noticed the deficiency in Grevilleas in certain areas. We are quite alive to this problem.

CHAIRMAN: We will open discussion on the other three papers.

MR GRICE: Red spider is our main problem. Of course, we have the scarlet, purple and pink mites and we are using various chemicals such as Ethion, Morocide, etc.

CHAIRMAN: Are you going into the question of systemic control?

MR GRICE: I am afraid no.

CHAIRMAN: Have you any problems with mites in Ceylon?

DR. KULASEGARAM: Mites are not very serious in Ceylon and if they are detected fairly early they can be kept easily controlled.

CHAIRMAN: You are very fortunate. On the question of blister blight have any systemic chemicals been tried in Ceylon?

DR. MANIPURA: This is outside my field, but I do not think that any systemic fungicide is in use in the field.

CHAIRMAN: We can now discuss Dr. Venkataramani's paper on clonal selection.

MR. PANDIARAJ: May we request Dr. Naik to let us have his comments on the papers presented today?

DR. NAIK: Mr. Chairman, I am most grateful for the opportunity you have given me to attend this Conference and say a few words. Let me at the outset tell you that I have not heen associated with the planters' problems and therefore I am unable to discuss them here.

However, there are some similar problems in the field of agriculture. I was particularly stimulated by the high standard of papers that were presented today and the high level of discussions that took place. Out of nine papers presented today, 5 were on plant protection and the remaining ones on clonal selection and fertilizer problems. This distribution was particularly interesting. Now-a-days there is considerable talk of green revolution, but I cannot think of green revolution without concentrating on plant protection measures. All our efforts in increasing agricultural production by the use of high yielding varieties and intensive fertilization will not bear fruit without protecting the crops against pests and diseases.

Thanks to the Ford Foundation for a grant of 50 lakhs of rupees and thanks to an important grant from UNDP, we are developing an Advanced Centre for research on plant protection in our Agricultural University at Bangalore. We will be concentrating generally on annual crops, but we would welcome collaboration with the UPASI Scientific Department in similar efforts on perennial plantation crops.

In the 1930s, when I was working on perennial fruit crops, I conducted a survey of orchard performance in an orchard with a stand of about 2000 mango trees. I found that only 2 trees out of some 2000 were yielding profusely and regularly. If only all the 2000 trees were high yielding, you could well imagine what the performance of that orchard could have been. I had a feeling that yielding potentiality was inherited, but some horticultural scientists with whom I discussed this were not quite sure about it. Dr. Venkataramani was not then associated with me, although

we worked together at a later stage. Dr. Venkataramani seems to have sorted out the inherent characters in tea including the cup quality. I am glad to learn that yielding poten iality is also inherited in the vegetatively propagated tea clones. This kind of work on fruit trees will be very useful indeed, as it has been on perennial plantation crops like tea

I feel greatly enriched by attending this Conference and I thank the UPASI for inviting me.

CHAIRMAN: Thank you very much Dr. Naik for those kind remarks and for some very interesting observations you have made. We are greatly honoured by your presence here today.

CHAIRMAN: Can we hear from the delegates from the T. R. I. of Ceylon of their work on clonal selection?

DR KULASEGARAM: We have been rather fortunate in having some high yielding clones. As Dr. Venkataramani pointed out we also associate the colour of the leaf and pubescence with quality, but we do have some clones which are very pubescent but with dark coloured leaf and they are not of good quality. I am interested in your method of selection which seems to be very reliable. So far our selection has been based on experience and the selection work has not been streamlined in the manner that Dr Venkataramani has described.

CHAIRMAN: Thank you very much.

CHAIRMAN: Have you grown any of our South Indian clones in Ceylon?

DR. KULASEGARAM: We have not been able to take any back! We have about 400 clones of our own of which only a handful are promising. We do not have any which have been able to surpass the 20 series.

CHAIRMAN: What about N.E. India?

MR. GRICE: Our aim is to rel ease a few tested clones every year and we have so far released 18 clones. In Be ngal we encourage the gardens to send their clones to the Research Station for further testing, particularly in relation to quality because in the garden their method of manufacture is not standardized. I would like to know whether there is any such scheme for testing garden clones in South India.

DR. VENKATARAMANI: At the moment we do not have any such scheme. But we propose introducing such a scheme in South India also.

MR. GRICE: There is just one other information, that is there has been no correlation between pubescence and quality and perhaps Mr. Choudhury would like to tell you something about this.

MR. CHOUDHURY: First of all I should like to support Dr. Venkataramani on his paper and say that the clone is the ultimate salvation for tea not only in N.E. India but also in South India. As an example I should like to mention that some of the gardens have been planting only clones as a result of which the prices have gone up by Rs. 4/- per kg. over the prices realised by the best Assam gardens. Regarding the relationship between pubescence and quality, at one time we thought that pubescence was directly correlated with quality. But later on we found that highly pubescent clones do not necessarily possess quality. Light coloured leaf definitely gives better liquor, but not necessarily better quality. Most of the quality clones are small leaved, which we have tried to avoid. In Tocklai we set a standard for

quality and we are fortunate that the industry as a matter of fact selected clones which meet this quality; some of the garden clones are much better than the Tocklai clones. As Mr. Cook mentioned, the tea gardens have a better scope for selecting clonal material than the experimental stations.

MR. PANDIARAJ: What are the chances of top working being introduced instead of uprooting and replanting tea?

MR. GRICE: More often than not when the tea declines the frames are sawed and the actual cutting of the top to top-work will kill the bush. Apart from this, it is impracticable to top-work on a field scale when shading of individual plant is essential.

CHAIRMAN: Yes, it is not a commercial proposition.

MR. RAMAKRISHNAN: A highly pubescent tea clone selected on an estate did not produce good black or green tea. How do we explain this?

DR. VENKATARAMANI: You were most unfortunate in spotting such a clone!

CHAIRMAN: Any more questions?

MR. ABRAHAM VARGHESE: In our selection of mother bushes we went for good spreaders leaving out those which showed a wine glass type of growth. But Dr. Venkataramani in his paper mentioned that good spreaders were not necessarily good yielders and he mentioned about orthotropic growth. Can I have a further explanation of this?

DR. VENKATARAMANI: It is not necessary that a tea bush with an orthotropic growth habit should produce a wine glass type of growth. With proper training at the initial stages, a good spread can be induced in such a bush.

DELEGATES' AGENDA

Question 1. Are plants capable of absorbing P_2O_5 through the leaf? Can the tea bush make use of the P_2O_5 in ammophos, when it is applied as a foliar spray?

Mr. Ranganathan: Plants are, in general, capable of absorbing P_2O_5 through foliage and tea is no exception to this. But several factors affect the efficiency with which P_2O_5 is absorbed and translocated within the plant. Some of them are soil and root temperature, intensity of light, form of phosphate, presence of certain chemicals like butyl alcohol, urea etc., pH of the spray solution and pH of the cell sap.

Our experiments have shown that tea can absorb P_2O_5 when applied through foliage as ammonium phosphate. But we do not know how far foliar application can replace soil application. In other crops, for example sugarcane, foliar application of P_2O_5 is only as effective as soil application and in some seasons it is ineffective as soil application. In apples, it has been found that only 12 to 14 per cent of P_2O_5 in fruits is derived from foliar applied P_2O_5. In potatoes and beans, foliar application is claimed to be 16 to 20 times as effective as soil application.

One should also remember that while 50 per cent of the foliar applied nitrogen is absorbed within $\frac{1}{2}$ to 2 hours, it takes 5 to 10 days for 50 per cent of the foliar applied P_2O_5 to get absorbed. There should be at least 5 clear days for 50 per cent of the foliar applied P_2O_5 to get absorbed. In monsoon months such dry spells rarely occur.

Question 2. In some crops, varieties with more vigorous vegetative growth have been produced ('GIGAS' character) by producing 'Polyploidy'. Has any work been done on tea in this direction to produce a big-leaved clone.

Dr. Venkataramani: Yes, some work has been done in this direction but with no fruitful results. I must mention first of all that all polyploids need not necessarily be useful commercially.

Some Japanese workers have reported having produced tetraploids (60 chromosomes) by treating diploids (30 chromosomes) with colchicine. Colchicine ploidy was tried by us as early as 1961, but with little success.

Polyploid tea plants occur in nature and from what I could gather triploids (45 chromosomes) appear to be useful horticulturally. For example, our selection 'Sundaram' is a triploid. Tetraploids, hexaploids (90 chromosomes) and plants with incomplete sets of chromosomes (32, 38, 40, 42 and 50) have also been reported to occur in nature. Work in this direction is in progress.

Question 3. Can the Scientific Department suggest any methods - cultural, manurial or chemical to reduce banji formation in tea bushes?

Dr. Venkataramani: This is a question which certainly deserves more attention than what has been bestowed to it hitherto. We know that the tea plant exhibits periodicity in shoot growth, There is a well marked rhythm in the growth of the shoots and one could readily discern periods of active growth (flushing period) and dormancy (banji period). The role of several factors - both external and internal - have been examined and there are so many apparently conflicting features about this phenomenon of periodicity of growth that no single explanation for it is possible.

An interesting paper on the physiology of leaf formation in tea was published by Dr. de Haan in the Dutch Journal Archief voor de Theecultuur in the year 1949. It appears to me that it has remained unnoticed, partly because the journal was not readily available and partly because the article has been written in an alien language. I have now managed to translate a section of the paper summarising the observations made in Indonesia and as it might be of some interest, I shall now reproduce it here.

"Young tea plants, without lateral shoots, growing in fertile soil under optimal conditions show a periodic growth. The normal growth process in tea is, therefore, periodic.

Climatic conditions such as rainfall, sunshine and temperature indeed influence the duration of the growth (flushing) and rest (banji or dormant) periods, but are not the cause of this normal periodicity. This would be apparent from the differing periodicity of individual plants and of the individual shoots in one and the same plant.

Leaf production is stimulated to a great extent by strong light (i. e little or no shade). If a bush growing at a low elevation and in full sunlight is regularly plucked and is thus stimulated to put on new growth it reacts by forming shoots which rapidly turn banji and symptoms of nitrogen starvation may appear. The leaves become small and yellow.

Mineral nutrition appears to have considerable influence on leaf production. If the soil conditions are favourable a rapid growth with plenty of flush shoots is obtained. If they are unfavourable, the proportion of banji shoots in the harvest increases.

Nitrogen supply is of particular importance in shoot development. With a low nitrogen supply many banji shoots are formed; with a high nitrogen supply, many flush shoots develop. As a rule nitrogen supply is not optimal in tea fields under plucking. (I would like to add here that this observation may have been relevant in 1949. Conditions have changed considerably since then and more nitrogen is now applied. Yet it is not unlikely that we are not making the proper use of fertilizers We have still to know how the frequency of N applications affect shoot production in tea).

Leaf formation can also depend on the assimilating surface area (i. e. the maintenance foliage). In a tea bush under plucking, normally carbohydrate supply may be generally sufficient and not limiting. Leaf production is also influenced by conditions in the interior economy of the bush. The centre of the bush produces more shoots, and in fact more flush shoots, than the periphery. Internal anatomical factors probably are responsible for the free flow of food towards the central shoots and initiate this difference in shoot production.

Shoot production in certain clones was investigated. It would appear to depend on the ability of the clones to develop many lateral buds and to branch freely. By analogy with the results obtained with other plants, it can be assumed that this depends on the activity of phytohormones. There are thus internal physiological growth factors which are characteristic of the bush and also of the clone and are inherited.

With the help of these findings a picture can now be formed of the growth process.

Various results indicate that the development of a shoot takes place faster than the formation of the quantity of food material required for it This growth, therefore, takes place at least partially at the expense of the stored food material.

The leaf of the first plucking after pruning contains more food material than that of the second plucking and this decreases gradually in subsequent pluckings until after a certain time it begins to increase somewhat.

It is a well known fact that shoots which form after a hard prune, that is when the entire food reserve in root system is available for only a few shoots, continue to grow for a long time before they pass into a resting stage. On the basis of these results, it is an obvious assumption that the cessation of growth, i. e. the passage to the banji stage, is brought about by the consumption of food supply.

The predominant influence of nitrogen supply shows itself in that regular leaf production depends on it. For the greater part the nitrogen compounds taken up (nitrates and salts of ammonia) are not used as such for growth, but in the form of complex organic compounds (viz. proteins). It naturally takes time before these accumulate in sufficient quantities in the buds, shoots and leaves for fresh growth activity. Proteins contain carbon and nitrogen in a definite ratio; in this sense one can speak of a certain C/N ratio which must be present to render possible a strong growth

A shoot begins to grow when a sufficient amount of elaborated food material (or a specific ratio of food material) has formed and when the remaining factors are favourable. These remaining factors are in the first place, the climatic conditions (adequate moisture) and further the internal factors, the removal of the limitation on the development by the action or by the cessation of action of phytohormones."

The nature of growth of the tea shoots, therefore, depends on the nutritional status of the plant as a whole and of each of the shoots individually and also the action of phytohormones.

Growth hormones and/or inhibitors may have a role on the periodicity of growth of the tea shoot and it is suspected that the maintenance foliage is the site of production of growth depressants. The whole question of the action of phytohormones on bringing about the periodicity of growth is at the moment a highly academic subject, nevertheless one which has to be actively investigated.

If banji formation is due to an inhibitor forming in the banji bud or leaf, extraction of such a substance and putting it back on the plant will not serve any purpose. A substance which would inactivate the growth depressant in the shoot or one which would promote growth by breaking the dormancy should be used. A preliminary trial carried out by us some years ago showed that Gibberellic acid would break the dormancy and activate the buds, but several spray applications of this growth substance may be required. The indications are that the cost involved would be in the range of Rs. 500/- per acre, which is surely uneconomical.

Question 4. There is a general belief that fine plucking - even if done at closer rounds - would reduce yields. It would be useful if the Scientific Department could detail their findings. Can we invite the planters' views on this?

Dr. Venkataramani: Very fine plucking involving constant removal of one leaf and a bud or two immature leaves and a bud will result in reduced yields. But if the first and the second leaf are allowed to expand fully, but not become coarse, and if such shoots are harvested, say at intervals of 7 to 8 days, such plucking, which can be classified as fine to medium, will not reduce yields. In fact in one of our pilot trials such plucking indeed resulted in increased crop over 10 and 14 days plucking, and the entire crop harvested was manufacturable.

I must mention that the entire leaf harvested from the 7 day plucking treatment was fit for CTC manufacture. In the case of the other two treatments, particularly in the 14 day plucking treatment, quite a lot of leaf was unfit for this kind of manufacture.

Mr. Choudhury: We do not use the term fine plucking in N. E. India, because it does not really tie up with the type of leaf we want in the factory. We go by weight, taking two leaves and a bud as fine and below two leaves and a bud as coarse leaf. We put a standard, say 75% of fine leaves during rains, and some people in Assam have gone up as high as 98 to 99% during the second flush period. And during rains they have come down to about 85%. This is the standard of fine plucking, but there may be a loss in crop of about 7%. But it is best to adopt fine plucking because of the good prices. In North East India especially in areas where one can produce good quality we cannot simply think of plucking coarse leaf. In areas where we do not produce such good teas we do not mind coming down a little bit on the quality of plucking. As Dr. Venkataramani has mentioned if you want to produce CTC teas you must have at least 75% of fine leaf.

Mr. Ranjan-Vijayaratne: Sir, I do not think that on shorter rounds one can necessarily pluck fine. It depends on what you leave on the bush for the next round. And it is possible to pluck coarse on short rounds and get fairly good leaf on even longer rounds.

Mr. Grice: In Darjeeling we pluck on 7 to 8 days and on these rounds we get a high standard of leaf, particularly during the first and second flush period. On the weight method it comes to 90% fines. On the plains, in Dooars, a good standard is 65% fines. If the standard is lower than this there is a reduction in quality, although there is no doubt that you do increase the crop by plucking coarse.

Question 5. How far can we expect the leaf to perform the functions of the root-system in collecting the plant nutrients?

Mr. Ranganathan: Plants are able to absorb nutrients applied to the foliage. Several factors affect the efficiency with which the nutrients are absorbed and I am not going to discuss them. Foliage can absorb nutrients, but the extent to which the leaf can replace the functions of roots as a nutrient collector is difficult to say. In sugarcane, foliar application of nitrogen is twice as effective as soil application of nitrogen, but it is so only when part of the nitrogen is applied to soil and not otherwise. While in the case of P_2O_5 foliar application is only as effective as soil application and in some seasons both methods of application are equally ineffective. The experience with other crops also suggest that foliar spray cannot entirely replace soil application as the root system has its own specific role to play in plant metabolism. Some of the secondary nutrients like calcium and magnesium and micro-nutrients like boron, iron and molybdenum have very little tendency to translocate when absorbed through foliage. In tea, we have started experiments for comparing the efficiency of absorption of nitrogen through soil and foliage but it is

too early to draw any useful conclusions. Therefore, we feel that soil application is still the major source of nutrients for plants. Part of the nutrients may however be supplied through the foliage as a supplement to soil application wherever quicker action is required, to correct deficiency of a nutrient, and when soil conditions are not conducive for efficient release of nutrients to plants.

Question 6. Would there be any appreciable difference in terms of yield if weed growth is controlled reasonably well by chemicals/manually – against attempting a 100% weed control spending very heavily in the first year (upto Rs. 350/-) and progressively less in later years.

Dr. Venkataramani: I would first of all like to know what the questioner means by 'reasonably well'. If he means the normal estate practice of letting a gang of workers hurriedly go through the field slashing or pulling the tall weeds – this is what generally happens in a number of places – then there will be a certain amount of crop loss as I have already told you this morning. If a field is horribly weedy with grasses and what not, then a sum of Rs. 350/- per hectare for weeding is not an unreasonable amount to achieve a satisfactory control of weeds in the first year of the pruning cycle. However, if the amount referred to is spent on weeding an acre of tea, then the answer is obvious.

Good weed control should be aimed at – weeds do suppress the tea crop. The information we have gathered shows that under normal conditions the weeding cost should be in the range of Rs. 50/- to Rs. 80/- per acre, provided chemicals are judiciously used and this expenditure could be gradually reduced in later years.

Question 7. Effective chemical weed control with paraquat at our elevation, seems to lead to the profusion of weeds resistant to this chemical particularly *Polygonum* and *Calceolaria mexicana.* Alternate chemicals not easily available were suggested for the control of these and manual removal had to be resorted to. Is there a solution suggested to this type of problem, which no doubt could arise even with the alternate chemical being a selective killer, again raising the spectrum of other resistant weeds?

Dr. Venkataramani: *Polygonum* and *Calceolaria* are resistant to Gramoxone but they can be controlled with a formulation based on 2,4-D.

A sodium salt of 2,4-D, say at the rate of $\frac{1}{2}$ to $\frac{3}{4}$ lb. per acre, could be applied once or twice combined with Gramoxone while spot spraying. In actual fact the anount of 2,4-D used will be much less than what I have just mentioned, because only patches showing growth of resistant weeds will be treated. A blanket spray of 2,4-D may also be given, say at the rate of 1.25 lb. of a 80% sodium salt per acre, in 40 gallons of water. If the spray application is done properly avoiding drift of spray to tea foliage, there is no risk in using 2,4-D formulations in tea.

Wherever necessary, we would also suggest the use of Simazine, say at the rate of 2 lb. per acre. Simazine will take care of such resistant weeds as *Polygonum, Calceolaria,* but this weedkiller has to be applied to clean soil and at a time when some rain is anticipated.

Question 8. Has any work been done on predators for mite control?

Dr. Rao: No regular work has been done on predators of mites for want of funds and staff. Studies of this nature involve a lot of spade work, over a period

of years. Whether or not such a project would ultimately be a success, the various predators of mites have to be collected, and multiplied and their life history, biology, ecology, host preference, efficacy as predators, release and recovery, effects of pesticides and other aspects have to be studied. Above all, the economics of such a project would also be required to be gone into.

We do know that there are a few predators occurring naturally in our tea fields. The more common among them are the lady bird beetles *Scymnus* and *Stethorus* and Phytoseiid mite, *Typhlodromus*.

In biological control, there is always a need for a minimum population density of the pest, in order that the parasite or predator may not disappear for want of its host. In some cases this minimum residual population of the pest is enough to cause economic damage. In such cases biological control does not work and chemical control has to be resorted to. Also, in cases where there is a pest complex, occurring at the same time, biological control cannot be thought of.

Question 9. In a 20″ to 21″ prune, what is the NPK mixture recommended in the year of prune and in how many applications?

Mr. Ranganathan: For a medium prune, if the frame is good and recovery from pruning is likely to be normal, no special manuring need be carried out. The fields may be manured on the basis of anticipated crop yields and the amounts of available nutrients present in the soil.

However, if the frame of the bushes are not healthy and drastic thinning of the stem is necessary for some reason or the other, then it is advisable to treat the pruned bushes as young plants and apply 1 : 2 : 2 NPK mixture in soils with low available P_2O_5 content and 1 : 1 : 2 NPK mixture in soils with a medium P_2O_5 status, limiting the amount of nitrogen applied to about 90 kg ha. The NPK mixture should of course, be forked in.

Question 10. Does the presence of shade in tea, reduce the water storage in dry weather? What variety of shade would you advise, for the Nilgiris, in areas particularly prone to prolonged drought to improve the water storage?

Dr. Venkataramani: Well, the answer for the first part of the question could be both 'yes' and 'no'. It depends on the proper or improper use of suitable or unsuitable shade tree.

If shallow rooted Albizzias are employed as shade trees, they could drain the soil. There will be a stiff competition between such shade trees and tea for moisture. In our experience we find that properly controlled or regulated shade helps in conserving the soil moisture at least in the top 18″ to 24″. Heavy mulch formed- and it has been calculated that pollarded grevilleas add as much as 5 tons of dry mulch material per annum – on the soil increases the organic matter content and moisture holding capacity of the soil.

In my advisory visits in the Nilgiri-Wynaad, Wynaad, Mysore and Central Travancore, where a distinct drought period ranging from 4 to 6 months exists, I have observed that tea under shade fares better than tea in fully exposed conditions.

It is unwise to make any generalised recommendation on the choice of shade trees I know this question comes from a high elevation estate on the Nilgiris and for that estate and most estates on the drier zone on the Nilgiris, I would suggest the use of Grevilleas as the principal shade. *Acacia elata* and *Acacia pruinosa* may

also be used. I must stress that there must be a set policy in establishing shade. Shade rotation is important and one should aim at a rotation of thinning out and planting in of shade trees so that shade trees are not retained in the field for very lengthy periods. The man on the spot, who knows the local conditions well and the growth habit of the plants, should be able to judge the economic life of the shade trees. Here again, it is unwise for us to lay down set dates for planting and thinning out shade trees.

Dr. Manipura: About two to four years ago all shade was removed in Ceylon and I do not think it was based on any experimental evidence but perhaps on opinion. In the up country where we do not get a drought I do not think shade is beneficial, but in the low country and in the Uva district where prolonged droughts are experienced, I think shade seems to be necessary. Apart from shade the shelter which the shade trees provide will be beneficial in most places.

Chairman: May I ask you whether you regretted removing all your shade in Ceylon?

Dr. Manipura: We have several experiments in the up-country tea but the results so far have not been conclusive, although there is an indication that the yield has gone up slightly after the removal of shade.

Mr. Grice: In N. E. India shade is essential and it is directly to cause a reduction in leaf temperature. Most of the shade you have here will be too heavy for use and we know that heavy shade reduces crop. We aim at a single canopy of shade, of one of the species of *Albizzia*, as high as possible to reduce the leaf temperature. In Darjeeling, in tea above 1500′ one need not have any shade for tea, i. e., with regard to China hybrid. But with large leaved Assam we would raise the elevation limit a bit. I am interested in hearing that you still advocate shade here; in Kenya and Malawi which have much the same kind of climatic conditions, they are removing shade in a big way.

Chairman: Of course we have strong land winds and the mite problem in S. India, but Dr. Venkataramani could probably amplify on this.

Dr. Venkataramani: Added to this, is the question of atmospheric humidity, which in South India is very low during the dry months. I do not think the same conditions exist in Kenya and Malawi. In Indonesia it is reported that the relative humidity never falls below 60 per cent for more than 2½ hours during the height of drought, but in our case in South India at mid elevations, between January and March, the afternoon relative humidity comes down to 15 to 18 per cent. Under such conditions we see bushes under shade flushing, whereas those in the open start to droop.

Question 11. What is UPASI's recommendation for planting distances for seedling and clonal plants?

Do any of the following factors influence planting distance:—

(a) annual rainfall pattern,

(b) whether replanting or new planting,

(c) Exposure of slope i. e., would you recommend that a different planting distance be adopted on a southern slope compared with a northern slope?

Dr. Venkataramani: From what I have seen here and elsewhere I think planting distance mainly depends on the vigour and growth habit of the tea plant, be it a seedling or a clone. For very vigorous growers, I would suggest a spacing of 4′ x 3′ (9000 plants/ha), but normally a spacing of 4′ x 2½′ (10750 plants/ha) or 5′ x 2′ should be adequate for most plants.

I do not think that there is any difference between replanting and new planting as far as the planting distance is concerned. The same planting distance or spacing may be adopted on all facings.

Fears are often expressed that lower rainfall areas may not support high plant populations. We have not had an opportunity to study this aspect, but it has been reported in literature that even in low rainfall areas in Nyasaland, except in an exceptional and severe drought of 1957, high plant densities were not seen to show any distress symptoms and it was concluded that closer spacing (planting density of about 10000 plants per hectare) appeared justified and economically desirable.

Dr. Manipura: I believe most of the comments made by Dr. Venkataramani are applicable to the conditions in Ceylon. The present recommendation of the T. R. I. of Ceylon is a planting distance of 4′ in between rows and 2′ between plants in the row, although for poor spreading clones still closer spacing might be adopted.

Chairman: What about North East India? Are you very much on the same lines?

Mr. Grice: We work about the same, 4′ by 2′ meets the upper requirements and 4′ by 2½′ meets the lower requirements. I think it is the planting material that determines the planting distance more than anything else.

Question 12. In the annual report for 1967-1968, the results of liming experiments are given on pages 81 and 82. Has any work been done since then? If so, what are the results and recommendations?

Mr. Ranganathan: Apart from the liming experiment reported in our Annual Report 1967–68, we have not carried out any fresh trials.

We have now critically analysed the results obtained in our experiment for the dynamics of organic matter content. We find that liming at the recommended rates do not alter the organic matter content of soils significantly. The mean annual soil temperature is much lower in the tea areas than in the plains and the annual precipitation is also considerable. Under these conditions, liming does not accelerate the decomposition of organic matter to any large extent as it does under high temperature and semi-arid conditions obtainable in the plains. Therefore, one need not have any fear of the possible adverse effect of liming on the organic matter content of tea soils, particularly when liming is done once in a pruning cycle and at rates of application recommended by us.

Question 13. Has the UPASI done any experiments on foliar application of nutrients, using concentration higher than 2%? If so, what is the highest concentration that could be used in mature tea without the risk of scorching? Is it advisable to mix fungicides (copper) and acaricides with the foliar spray?

Mr. Ranganathan: We have carried out the following trials on foliar application of fertilizers:

1. Foliar application of potassium and NPK solution used was 3.25 per cent (Urea 1.25 per cent, super phosphate 1.0 per cent muriate of potash 1 per cent). The bushes responded to the applications of potassium and NPK.

2. Foliar application of ammonium phosphate: spraying of ammonium phosphate at 1.5 per cent concentration was found to be beneficial in increasing the yield of tea.

3. Observational trial to find out the maximum tolerant concentration that could be used in foliar sprays in tea: Solutions of urea, potassium sulphate, magnesium sulphate, zinc sulphate and aluminium sulphate at concentrations ranging from 1 to 5 per cent were sprayed at 80 to 90 gallons per acre. Leaf scorch was noticed on plants sprayed with 3 per cent or more of zinc sulphate and 4 per cent or more of aluminium sulphate. With urea, potassium sulphate and magnesium sulphate, we did not observe any scorch upro 5 per cent concentration. But in another trial where we sprayed urea at 5 per cent concentration using a mist blower at 30 gallons per acre, we noticed scorching of tender leaves. Similarly at concentraiions above 2 per cent, ammonium phosphate sprays showed scorching effect on leaves. Therefore as a safe measure, we recommend using 1.5 per cent solution of ammonium phosphate and 2 to 3 per cent solution of urea for foliar application.

Mixing of the above chemicals except urea with copper oxychloride suspension was found to affect the suspensibility of the fungicide adversely. In the case of a combined spray of copper fungicide and ammonium phosphate the entire copper is immediately precipitated as copper phosphate. The particle size of the precipitate is large and thus very efficient protection against blister blight is not afforded. We would, therefore, dissuade members from adding ammonium phosphate to copper fungicide sprays as far as possible.

Question 14. How does soil acidity affect the assimilation of potash and magnesium? In soils of high acidity (pH less than 4.5) is it advisable to apply potash to the soil? If so, what is the highest dose?

Mr. Ranganathan: Acidity of the soil is due to hydrogen ions replacing metallic cations like calcium, magnesium and potassium. It is, therefore, obvious that the amount of these cations will be low in acidic soils. Added to the low amount, these cations especially potassium ions, are weakly held by the clay colloids and hence are liable to be lost by leaching. Moreover the excess acidity and the consequent acid soil cations (hydrogen, soluble aluminium, iron and Manganese) reduce the activity of potassium in soil solution - or in popular terms reduce the ease with which the plants can utilize them. Therefore the amount of potash required for an extremely acid soil to give the same response is higher than in the relatively less acid soil. The increased rate of application so required is to compensate for the losses by leaching and reduction in the activity of potassium ions. It is difficult to fix up a highest dose of potash for an extremely acidic soil as potash requirement also depends on the nitrogen status of the soil, the previous history realting to crop yields and drainage and depth of soils which have a bearing on the volume of soil explored by the roots. But broadly, we can say, that the amount of potash required varies from 50 to 70 per cent of the total nitrogen applied depending on the various factors referred to above.

Similar reasoning also applies to magnesium but magnesium is less leached than potassium. Moreover the plant's requirement of magnesium is generally low. Hence magnesium does not pose a problem under normal conditions. However,

magnesium assimilation may be affected when (i) the exchangeable magnesium content of the soil is very low, say less than 60 ppm. as in some extremely acidic soils and in soils of high potassium status. Tea soils, in general, do not have a high soil potassium status and we, therefore believe that under the levels of potassium application which we recommend potassium will not affect magnesium availability. Recently we came across a few instances of magnesium deficiency in some extremely acidic soils with low magnesium content. In these cases, symptoms of magnesium deficiency appeared in the wet months and disappeared as the dry weather set in. Divalent cations like calcium, magnesium etc. are more readily absorbed from a concentrated soil solution than from a dilute soil solution, compared to a monovalent ion like potassium. That is why symptoms of magnesium deficiency appear during monsoon months when the soil is saturated with water; this is particularly so in soils with a low magnesium content, However, when dry conditions set in, absorption of magnesium becomes normal and the symptoms disappear. This condition is usually expected in the early stages of magnesium deficiency. In extreme cases, symptoms of magnesium deficiency, may be seen throughout the year. The use of magnesium limestone and/or dolomite as liming materials will be beneficial to increase the magnesium content in soils.

Question 15. What should be the optimum C/N ratio for South Indian soils – (a) elevations above 4,000 ft. (b) below 4,000 ft.? How will the organic matter content of the soil affect the assimilation of potash and phosphate?

Mr. Ranganathan: C/N ratio in soils depends on many factors like soil temperature as affected by latitude and altitude, annual precipitation, intensity of cultivation and to some extent on soil texture. C/N ratio is an equilibrium property or a characteristic value of organic matter in soil for a particular annual rainfall and soil temperature. This characteristic value may show seasonal variations depending on the time lag between fertilizer application and the sampling date. The C/N value which we consider normal for the various tea soils of South India can be calculated from the equations given below:

The characteristic C/N ratio

		Young tea fields	*Mature tea fields*
Per humid regions with annual rainfall above 100 inches	Log C/N	1.1052 — 0.0007 T	1.1230 — 0.0001T
Humid regions with 50-100 inches of annual rainfall	Log C/N	1.1861 — 0.0013 T	1.5043 — 0.0057 T

where T — Annual mean temperature in °F which depends on altitude and latitude and to some extent on the facing in hilly terrain.

The organic matter content in the soil increases the nutrient holding capacity of the soils, thereby increasing the retention of potassium in larger quantities. Therefore organic matter content in the medium ranges help in the better utilization of added potassium by increasing the retention of potassium in the soil. But with high organic matter content the activity of potassium in the soil solution is reduced and hence plants have to spend more energy to utilize it than when the activity of potassium is high. Hence to increase the activity of potassium in soil solution for easy absorption by plants, more potassium has to be added than what we normally add to the soils with low and medium organic matter contents. Some of the other effects of organic matter in the soil are (i) the improvement of soil structure thereby facilitating root exploration of large volume of soil and (ii) the increase of the water holding capacity of soil, thereby maintaining a moist condition which helps in the efficient utilization of potassium.

Decomposing organic matter has a decided effect on the solubilisation of native and added phosphates and making phosphates readily available to plants. The effect is more pronounced in the anerobic sub-soil than in the aerobic surface soil. This is one of the many reasons for advocating placement of phosphate fertilizers in the soil.

Question 16. There is a general impression that zinc deficiency is spreading to the higher elevation. Is there any experimental evidence to support this? What are the UPASI recommendations? Is there any relationship between soil acidity and zinc deficiency? If so, what are the corrective steps to be taken?

Dr. Venkata Ram: Rather than being merely a general impression on that zinc deficiency is spreading to higher elevations, it will be more appropriate to say that the occurrence of zinc deficiency at all elevations is factual. On the Nilgiris and the High Ranges, which represent our high elevation teas in S. India, zinc deficiency is now known to be widespred and in certain areas it is prevalent in a severe form. We are making these statements on the basis of actual visual observations. On the Nilgiris the results of foliar application on zinc sulphate in accordance with our Department's recommendations have been dramatic. We must here emphasize that response to zinc sulphate in tea deficient to this element will be good provided that general plant husbandry is sound. If 2 to 3 week plucking rounds are maintained, it is difficult to see how the effect of zinc sulphate treatment could be reflected as crop increase, though the symptoms on the bush will disappear.

Zinc deficiency occurs at all soil pH regimes under which tea is cultivated in S. India. When the soils are very strongly or extremely acidic, that is at pH below 5.0, the availability of zinc to the tea plant decrases in direct relationship to the drop in pH. Hence it is to be expected that zinc deficiency will be accentuated at soil pH below 5.0, especially when the tea is high yielding and there has been a drain on the zinc originally carried by these soils. High organic matter and high clay content of soils would also lead to fixation of zinc, therefore, in such soils tea is likely to manifest moderately severe to severe deficiency symptoms if zinc salts are not incorporated to replenish the loss of this element by removal over a period.

The corrective steps against zinc deficiency are simple. Application of zinc sulphate as foliar spray at 10 lb. per acre, preferably put out at the rate of 2 lb. at 15 day intervals, five times, along with the blister blight spray, in alternate years will in most of the cases eliminate zinc deficiency as a limiting factor. In certain instances the level of zinc sulphate may have to be stepped up to 15 or even 20 lb./acre. Soil application with zinc salts will also correct zinc deficiency, but in this case the quantity to be applied per acre has to be substantially larger than what is suggested for foliar application.

Question 17. In the proceedings of 1967 Scientific Conference, there is an article on the 'Economics of fertilizer use in tea' and from the data given in table 1, an application of 245 lb. of N/acre appears to be most economical. Does this apply to all elevations or only below 4000 ft? Has the UPASI collected any further data?

Mr. Ranganathan: At the outset, I should like to point out that what is given in the article cited in the question as the optimum dose is only an example for arriving at the economic dose by field experimentation for the particular conditions obtainable in the field in which the experiment was carried out. The economic dose of fertilizer depends on many factors like the initial fertility of the soil, the ability of the crop to utilize the nutrients etc. As the initial fertility of the soil depends to a large extent on the accumulation of organic matter which is a function of altitude and precipitation, variation in the organic matter content itself takes into

account the major differences in evaluation of economic doses which we might expect from the variations in altitude. We have already discussed in detail this morning how economic doses are arrived at based on soil analysis and crop yield.

Question 18. Will the UPASI kindly prepare and publish a guide on the approved clones under the following headings:

(1) Rooting habits and form of growth, (2) Liquor (3) Yield, (4) Suitable for all elevations, (5) Suitable for only high or medium elevations, (6) General replanting (7) Infilling?

Dr. Venkataramani: Yes, Sir, this will be done. We have information on all our selections, but we would like to receive full particulars of the clones selected by member estates,

Question 19. Has the UPASI conducted any field experiments to find out whether forking in or placement of the fertilizer is more advantageous than broadcasting? If so, what are the results? Also, should 'N' nutrient be broadcast and whether P and K should be forked in?

Mr. Ranganathan: We are now carrying out a trial to study the effect of different methods of application of fertilizers This experiment has run only for a short period and as such we are unable to analyse the figures and derive any useful information as yet.

A specific recommendation on the methods of applying different nutrients depends on the movement of fertilizer salts within the soil.

Nitrogen is highly mobile and it tends to move from the zone of placement. This movement is mostly vertical in the sub-humid region, but also horizontal in the humid regions. The tendency for vertical movement of the nitrates is taken advantage of when broadcasting is done. Therefore nitrogenous fertilizers can be broadcast. However, to reduce the losses of nitrogen by volatilization, it is desirable to dibble in the broadcast fertilizer with a 'kokra'.

Phosphatic fertilizers are immobile in the soil and are fixed readily. They do not move out of their zone of placement. Tea roots are able to utilize phosphorus by mere contact with phosphatic fertilizer particles – this phenomenon is known as contact-exchange feeding. For the effective use of phosphorus phosphatic fertilizers have to be placed in the root zone. The solubilization of phosphorus in soil and absorption by plants are more in the relatively less oxidised sub-soil than in the well aerated surface soil. Moreover, phosphate concentration gradients formed at micro distances around the phosphatic fertilizers placed in the sub-soil form potential centres of absorption by the plants. For reasons outlined above, we consider that phosphates are better utilised when placed than when they are broadcast. In our preliminary studies on phosphorus nutrition, we have observed that the sub-soil phosphorus contributes more towards crop nutrition than the surface soil phosphorus. We, therefore, feel that we should aim at building up the phosphorus status of the sub-soil.

We prefer placement of potassium for the following reasons:

1. The rate of absorption of potassium by tea is dependent on the concentration in soil solution. Placement of potassium fertilizers facilitates localised high concentration pockets for easy absorption by the roots. Broadcasting on the other hand dilutes the concentration of potassium obtainable in the soil solution and thereby the efficiency of utilization of potassium is reduced.

2. The loss of potassium by leaching in the percolating and run-off water can be reduced to the minimum if potassium is placed. This is important when we consider the low nutrient holding capacity of tea soils, weak bonding of potassium in kaolinite clay minerals and heavy illdistributed rainfall.

3. Tea roots utilize sub-soil potassium in the relatively dry periods when the surface soils are desiccated. Therefore, building up of the sub-soil potassium helps to meet the demands of the crop during summer months.

In our manurial experiments by placing the NPK fertilizers and dibbling in the nitrogenous fertilizers we have maintained yields ranging from 1800 to 2500 lb. of made tea per acre with 80 to 140 lb. N, 20 to 48 lb. P_2O_5 and 40 to 80 lb. K_2O. These levels are lower than the 10 to 12 lb. nitrogen ratio widely used by many estates for maintaining such yields. We admit that we have not compared placement against broadcasting in any of our earlier experiments. We expect our present trials to give us some useful information on this.

Question 20. Will the nutrients if given more affect the leaf quality?

Mr. Ranganathan: This question has been repeatedly raised in our conference in one form or the other. The position upto 1958 has been summarised in the article, 'A discussion on the relation between quality and manuring' appearing in the Tea Quarterly for March 1958 in which it is reported that there is no relation between the intensity of manuring and quality of made tea, provided proper harvesting, handling and manufacturing methods are followed.

There is always a limitation imposed on the nutrient contents of tissues and the crop cannot take more than the amount which the tissues can tolerate unless the absorbed nutrients can be diluted by increasing their growth. Therefore, we expect very little difference in quality arising from the use of fertilizers.

In the past, we have had occasion to study the effect of increased rates of potash and zinc applications on the crude fibre content of made tea. We have found that the crude fibre content is not affected by increased doses of these nutrients.

A recent report from East Africa mentions that application of phosphate fertilizers increases the cup quality of tea. The results reported, however, were based on a single assessment and we find it difficult to place much reliance on such an assessment. We have not found any difference in quality brought about by increased applications of phosphates.

Similarly urea is reported to increase the quality of made tea in Japan. We have also heard it said that it adversely affects the quality. In our experiment we have not had any consistent results.

To sum up, we do not have any precise information on the effect of plant nutrients on the quality of the made tea.

Mr. Choudhury: We have some data on the relationship between nitrogen and leaf quality. We find that if the rate of nitrogen application is very high we lose quality. Our application rate is a maximum of 200 kg. of nitrogen per hectare and under such conditions we do not notice any loss in quality.

Mr. Grice: Work done quite a long time ago in Tocklai showed that whatever you do to increase the crop slightly depresses the quality, but that this was not noticed until the crop was doubled.

Chairman: Interesting, it is quite a simple formula !

Chairman: What about Ceylon ?

Mr. Warusavitarane: I had mentioned that in Ceylon we got very high yields of over 6000 lbs. per acre and this tea was manured at a very high rate. Yet we did not experience any loss in quality.

Chairman: Any further questions before we close the session ?

Mr. Vijayaratne: May I know what your experience is with mechanical plucking ?

Dr. Venkataramani: Our Department has not carried out any work on this. My planter friends may be in a position to answer this.

Mr. Abraham Varghese: We have done quite a bit of mechanical harvesting and we think that it tends to be a bit hard on the bush, unless we go back to hand plucking periodically.

Chairman: In South India that is the general experience. We were all enthusiastic over it about 4 years ago but everybody is losing heart on it now.

Mr. Warusavitarane: Are you referring to shear plucking or machine plucking ? Shear plucking has not been very successful, but I have done some mechanical plucking with a Japanese mechanical plucker running on 1/8th h. p. engine. 300 to 350 lb. of leaf could be harvested per day with two workers, one for running the machine and one collecting the leaf, but the leaf was not very selective.

Chairman: What happend to the quality of tea ?

Mr. Grice: In North Indian experience, with mechanical plucking the yield is reduced almost immediately and the quality of the tea is not quite as good as with hand plucking.

Mr. Vijayaratne: I would like to ask whether you are doing any work on soluble teas or instant teas.

Dr. Venkataramani: Some work is being done in the country at the C.F,T.R.I., Mysore, and in the Biochemistry Department of the University of Calcutta.

Mr. Sethna: I would like to hear what is being done in Ceylon ?

Mr. Warusavitarane: The C.S.I.R. of Ceylon is experimenting with different forms of tea and we have produced a bottle of tea with lemon flavour which is cross between Coca Cola and Guinness (Laughter).

Dr. Venkataramani: We are also working on these lines.

Mr. Vijayaratne : We have also marketed a canned tea preparation recently.

Mr. Mayow : Dr. Venkataramani gave a list of tea clones for South India. May I ask whether he has tested them for compatibility in manufacture and whether these clones which are selected for quality and flavour are fully compatible?

Dr. Venkataramani: We have done some work; out of the 23 clones listed 6 or 7 are compatible and they could be planted together.

Chariman : Gentlemen, we now come to the end of the Conference. It has been quite interesting, I personally thought that the papers were of a high standard. I see considerable progress in the work of the Scientific Department. I am also impressed with the density of the crowd during the afternoon session.

I am very grateful to you, Ladies and Gentlemen, for sticking out for such a long time and to the Director and his staff for obviously spending a lot of time in preparing the interesting papers. I can see a new approach all through. I must also congratulate the persons concenrned in the slide arrangement. I would also like to express my gratitude to the representatives of Tocklai and Ceylon for coming down and participating in the Conference.

Finally, I do hope you had an interesting day and that you have learnt something. If you have any further queries on today's conference I am sure Dr. Venkataramani will be delighted to amplify and clarify.

Mr. Mohan Rao : Mr. Chairman and Dr. Venkataramani, we the Officers of the Government Cinchona Department have been very greatly benefited by this Conference. We have almost similar problems on aromatic and medicinal plants which we are growing and I always found that the papers presented in these Conferences have been of immense value in our work. I have been attending these conferences over the last 10 years and I am glad to say that the standard of papers presented today is very high and that they have been gaining new height every year. This morning Dr. Venkataramani took us on a whirlwind tour of the work over the last 25 years and at the end of the tour I am left with the impression, which I have no doubt you will all share, that all along the UPASI Scientifc Department is bringing to bear the practical approach on all its problems rather than the academic approach.

On behalf of the Tamil Nadu Government I thank you all for giving us an opportunity to participate in this Conference.

Chairman : Thank you, Mr. Mohan Rao.

Chairman : I declare the meeting closed.

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